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SPECIFICATIONS AND CLAIMS OF PATENT APPLICATION

Power Cogeneration System And Apparatus Means For Improved High Thermal Efficiencies and Ultra-Low Emissions

BACKGROUND OF THE INVENTION

To achieve a goal of significantly reducing a ~~turbine~~ power cogeneration system's ~~mass~~ emission mass flow rate of the "greenhouse gas" (carbon dioxide) by a given percentage amount, it is necessary to proportionally increase the thermal efficiency of a power unit apparatus' conversion of fuel energy to developed mechanical power and useful applied residual thermal energy ~~cogeneration system~~ which therein proportionally reduces the amount of combusted hydrocarbon fuel required to provide the described energy conversion ~~into a given amount of required work and usefully applied residual heat energy~~.

It has been well known and practiced for decades that higher humidity air and injected water or steam commingled with conventional air combustion gases increases combustion flame speeds and fuel combustion thermal efficiencies within gas ~~turbines~~ turbine type engines, reciprocating type engines, and other fuel combustion burner apparatus using air/fuel combustion. It has also been well known and practiced that partially re-circulating combustion flue stack gases containing carbon dioxide

(CO.sub.2) back into a combustion chamber results in a reduced level of nitrogen oxides (NO.sub.x) within the fuel combustion exhaust gases. Due to the high temperatures and speed of completed fuel combustion, the scientific community has been unable to reach a consensus as to precisely what series of altered chemical reactions occur when water vapor and/or carbon dioxide is introduced into ~~a turbine~~ an engine's fuel combustion chamber assembly or subassembly device.

Oxy-fuel combustion burners have been employed for many years in the steel and glass making industries to furnish desired 3000+ degree Fahrenheit combustion gas temperatures into furnaces to avoid the production of high ~~NO.Sub.x~~ (NO.sub.x) emissions, ~~(~~ but at the expense of high carbon monoxide (CO) emissions ~~)~~. Both the present air separation art methods' high production energy costs of producing acceptable combustion grade oxygen, and the lack of devised combustion system methods to control preset desired oxy-fuel combustion burner or combustion chamber assembly or subassembly uniform maximum temperatures, have collectively curtailed oxy-fuel combustion applications within present fuel thermal energy to power energy conversion facilities.

Conventional gas turbine engines ~~turbines~~ or reciprocating engines must be de-rated from their standard ISO horsepower or kW ratings at ambient temperatures exceeding 59° F, and/or at operating site altitudes above sea level. Thus, during summer's peak power demand periods, when the ambient temperature can increase to 95° F or greater, up to 20% to 25% horsepower derations of a conventional gas turbine's ISO engine rating can occur. It is obviously desirable that a power turbine engine/generator unit apparatus within a cogeneration system not be susceptible to

such combined on-site ambient temperature and altitude derations when peak power demands occur, or at any other time or site location.

The current and future projected increasing costs of purchased utility electric power and natural gas (or liquid hydrocarbon fuel) and the accepted projected future trend in the future of "distributed power" and/or power cogeneration facilities, coupled with present and future environmental constraints on fuel combustion exhaust emissions, will make it commercially mandatory that such "distributed power" and/or power cogeneration facilities have the combined attributes (at the minimum) of combined ultra-low NO.sub.x and CO exhaust emissions and substantially higher thermal efficiencies than offered by current art power cogeneration methods. It can be expected that the number of new turbine engine powered 'cogeneration facilities in the world will be significantly greater than the number of turbine engine powered 'combined-cycle' facilities that are devoted purely to the production of electric power. The referenced 'cogeneration facilities' are not new in concept. Such energy saving facilities became highly popular in the 1970's (then referred to as 'Total Energy Plants') and were aggressively promoted by many natural gas utilities. Reciprocating gas engine-driven generator sets were the predominant producers of prime power and utilized waste heat. These 'Total Energy Plant' facilities efficiently provided electricity, hot water or steam for domestic hot water and building heating requirements, and chilled water for air conditioning. 'Total Energy Plants' were widely applied to serve hospitals, universities, large office buildings or building complexes, shopping centers, hotels, food processing plants, and multi-shift manufacturing and industrial facilities, etc. The 50 plus years old predecessor to the 'Total Energy Plant' concept was the central electric power and steam plants that continue to currently serve some large eastern US cities, and more

predominantly European cities and metropolitan areas. Predominantly, 'Total Energy Plants' and current cogeneration facilities have predominantly had less than 100 psig utility supplies of natural gas available to their facilities.

It is not unusual that present art cogeneration facilities can require fuel gas compression apparatus assemblies to supply adequate fuel pressure to the employed cogeneration method's selected power engine units, with the said fuel gas compression consuming approximately 5% of the gross electric power produced by the current art power cogeneration facility. It is therefore desirable that power cogeneration facilities incorporate a fuel energy to power and useful heat energy conversion method that requires low gas supply pressures.

When Brayton ~~Simple~~ Cycle gas ~~turbines~~ turbine engines operate within current art cogeneration facilities as mechanical power drive sources to electric generators and other mechanically driven devices, atmospheric air is compressed and mixed with hydrocarbon gases or atomized hydrocarbon liquids for the resulting mixture's ignition and combustion at approximately constant pressure. To produce power, the hot combustion and working motive fluid gases are expanded to near atmospheric pressure across one or more power extraction turbine wheels, positioned in series.

The majority of Brayton simple open-cycle aero-derivative-style Low-NO.sub.x art gas ~~turbines~~ turbine engines are predominantly presently limited in achieving shaft output horsepower rating with 26% to 39% thermal efficiencies, whereas most simple cycle industrial-style Low-NO.sub.x art gas ~~turbines~~ turbine engines are predominantly presently limited in achieving shaft output horsepower rating with 27% to 34% engine thermal efficiencies. The aero-derivative turbine engine's higher efficiencies are achieved when the gas ~~turbines~~ turbine engines operate with compressor ratios ranging

from 14 to 35 and predominant first stage turbine inlet temperatures ranging from 2000° to 2300° F. Typical turbocharged reciprocating-type power engine units generally have 3% to 5% higher output shaft thermal efficiencies than comparable power rated gas turbine power units having lesser overall life cycle operating costs.

Existing conventional applied art gas ~~turbines~~ turbine and reciprocating-type engines employ combustion chamber air/fuel combustion chemical reactions, wherein the elements of time and high peak flame temperatures increase the presence of disassociation chemical reactions that produce the fugitive emissions of carbon monoxide (CO) and other chemical reactions that produce nitrogen oxides (NO.sub.x).

The best available applied turbine engine and reciprocating-type engine low NO.sub.x combustion technology for limiting ~~gas turbine~~ NO.sub.x emissions, using near-stiochiometric air/fuel primary combustion reaction chemistry means, still results in the production of NO.sub.x and CO that are no longer acceptable for new power or energy conversion facilities in numerous states and metropolitan environmental compliance jurisdictions. With the conventional gas ~~turbine's~~ turbine engine or reciprocating-type engine ~~use~~ employment of compressed atmospheric air as a source of oxygen (O.sub.2) which acts as a fuel combustion oxidizing reactant, the air's nitrogen (N.sub.2) content is the approximate 78% predominant mass component within the cycle's working motive fluid. Due to its diatomic molecular structure, the nitrogen molecules are capable of absorbing combustion heat only through convective heat transfer means predominantly resulting from their collisions with higher temperature combustion gas molecules ~~or higher temperature interior walls of the combustion chamber~~.

Despite the very brief time it takes for conventional ~~gas turbine~~ power engines to reach a average molecular primary flame combustion zone gas equilibrium temperature of less than 2600° F within its combustion chamber assembly or subassembly, there are sufficient portions of the combustion zone gases that experience temperatures in excess of 2600° F to 2900° F for an ample period of time for the highly predominate nitrogen gas to enter into chemical reactions with oxygen that produce nitrogen oxides. The same combined elements of time and sufficiently excessive high flame temperature permit carbon dioxide to enter into dissociation chemical reactions that produce carbon monoxide gas.

To achieve a goal of greatly reducing a ~~turbine~~ power engine unit's ~~NO.Sub.x~~ NO.sub.x and CO fugitive emissions, it is necessary to alter both the fuel combustion chemical reaction formula and the means by which acceptable combustion flame temperatures can be closely controlled and maintained within a power ~~turbine~~ engine unit's fuel combustion assembly. Maintenance of an acceptably low selected fuel combustion peak gas temperature at all times and throughout all portions of within the combustion assembly, requires a change in the means by which the heat of combustion can be better controlled and more rapidly distributed uniformly throughout the gases contained within the fuel combustion assembly.

Summary of the Invention

To achieve both power turbine engine ultra-low NO.sub.x and CO exhaust emissions ~~(~~ as well as reduced "greenhouse gas" carbon dioxide (CO.sub.2) emissions and enhanced simple-cycle operating thermal efficiencies, the inventor's AES gas turbine power cycle system and apparatus is described in U.S. Patent # 6,532,745 dated March 18, 2003. The cited invention's further described partially-open gas turbine

cycle contains multiple heat recovery devices for transferring waste heat to varied process gases and steam resulting in a cogeneration facility overall maximum thermal efficiency that "may approach 100%".

The present invention describes selected process elements from ~~the means by which~~ the cited partially-open AES turbine power cycle ~~system~~ and apparatus devices that can be incorporated ~~into~~ within a simplified and improved ~~gas turbine~~ power cogeneration system method having simplified apparatus means ~~and~~ that can further achieve increased ~~turbine~~ power cogeneration method system and apparatus thermal efficiencies which ~~exceeds~~ may exceed115%.

~~The present invention further describes the alternative system and apparatus means for the cited improved partially-open turbine cogeneration system that can be employed within a desired power cogeneration system design, the said alternative system and apparatus means incorporating portions of the AES heater cycle system and apparatus content cited in the inventor's U.S. Patent application 10/394847 filed March 22, 2003 and titled "Partially-Open Fired Heater Cycle Providing High Thermal Efficiencies and Ultra-Low Emissions".~~

The addition of these selected apparatus assembly device alternatives to the presented power cogeneration method employing a power engine unit of the example gas turbine engine type ~~based cogeneration system~~, as later further described and shown in Figure 2, ~~can~~ may increase the presented power cogeneration system's method overall thermal efficiency to greater than 115%.

~~The commercial viability of achieving maximum reductions in the presented invention's enhanced cogeneration system's fuel operating costs (with accompanying reduced NO.sub.x, CO, and CO.sub.2 exhaust emissions is assured by the presented~~

~~invention's oxy-fuel combustion system's access to a facility-provided ultra-high electric energy efficient modular air separation system providing a 93% to 95% purity predominant oxygen fuel oxidizing stream, such as presented in the inventor's U.S. Patent Application 10/658157 dated September 9, 2003 and titled "Pure Vacuum Swing Adsorption System and Apparatus" that provides a 75% reduction in kWh/Ton oxygen.~~

To achieve the power cogeneration method system's ultra-low fugitive exhaust emissions, the ~~cited partially-open~~ presented power cogeneration system method employs a partially-open gaseous thermal fluid energy cycle and apparatus ~~means~~ assembly devices that provides a continuous controllable mass flow rate of described recycled or "recirculated" superheated vapor-state predominant mixture of carbon dioxide (CO.sub.2) and water vapor (H.sub.2 O), the said mixture being in identical mixture Mol percent proportions as each said molecular gas component occurs as products of chemical oxy-fuel combustion reactions from the gaseous or liquid hydrocarbon fuel employed.

To achieve the power cogeneration ~~system's~~ method's ability to employ gaseous hydrocarbon fuels, other than gas utility distribution quality natural gas, the cited gaseous fuels (alternately containing toxic and/or difficult to combust hydrocarbon molecular gases) can be rapidly carried through useful fuel energy to useful heat conversion and/or completed incineration with the inventions provided system method and apparatus ~~means~~ assembly devices ~~to~~ that control the primary and secondary combustion zones temperature. Whereas the invention example ~~system's~~ system method presented recycle exhaust gas (or alternately referred to as "recirculated cycle gas") flow rates and temperatures are capable of producing 1800°F tertiary zone ~~combustion~~ working motive fluid gas temperatures to the example gas turbine engine's

power turbine wheel sub-assembly (while maintaining herein described high thermal efficiencies and ultra-low emissions), the preferred example 2400° F primary and outer secondary zone combustion temperature provides a desired 7.585 greater chemical reaction speed rate between a fuel and oxygen than that occurring at 1800° F. As repeatedly verified by John Zink Research in applied research, the reaction rate formula is:

$$\text{Reaction Rate Increase} = (N) = \frac{[(2400^\circ\text{ F} + 460) \div (1800^\circ\text{ F} + 460)] - 1}{.035}$$

Provided herein is ~~both~~ a ~~partially-open turbine~~ power cogeneration system method with apparatus ~~means~~ assembly devices employing a partially-open gaseous thermal fluid energy cycle for use therein of either the provided example modified conventional gas turbine power engine unit configurations, or use therein of the alternative ~~AES~~ unconventional turbine power engine assembly unit apparatus configurations that can utilize separate existing low cost mechanical equipment apparatus assembly components and ~~burner assemblies~~ combustion chamber assembly or subassembly devices. The said assembly components need not to be ~~which are predominantly not~~ designed for, nor applied to, either the manufacture of conventional ~~gas turbines~~ engine power unit assemblies nor the said apparatus devices ~~components~~ and ~~burner~~ combustion chamber assemblies or subassemblies incorporation into facility designs of current technology ~~gas turbine~~ engine powered cogeneration ~~systems~~ facilities (or combined-cycle ~~systems~~ facilities). The cited combustion chamber assemblies or subassemblies devices are those wherein fuel combustion occurs at pressures greater than 1.5 bar absolute.

The invention's combined employed cited ~~partially-open gas turbine cycle system~~ power cogeneration method and apparatus, a partially-open gaseous thermal fluid

energy cycle, and the alternative added ~~cited AES heater cycle system and~~ incorporation of an oxy-fuel burner apparatus (having a fuel combustion pressure of less than 1.5 bar absolute) ~~portion~~ into the present invention therein provides for a commonly 'shared non-air' working motive fluid means that is essential to the 95% to 100% reduction of NO.sub.x, and CO mass flow emissions from those of conventional ~~Low-NO.sub.2~~ Low-NO.sub.x designed gas ~~turbines~~ turbine and reciprocating engines and/or other conventional fuel combustion ~~burner~~ apparatus devices that can be applied within existing art power cogeneration ~~systems~~ methods and employed apparatus devices.

It is an objective of the present invention's improved power cogeneration method system and apparatus means to provide a new benchmark standard for Best Available Technology (B.A.T.) in achieving combined highest thermal efficiencies, lowest emissions, and lowest auxiliary facility operating power consumptions within a overall operating power cogeneration facility.

It is a further objective of this invention to provide the means by which the power cogeneration method system's production of steam or hot water, and/or the heating of process fluids, is not limited by the amount of a ~~turbine~~ power engine unit/generator or power engine unit/mechanical drive train's ~~available~~ availability of waste heat that can be derived from a given production level of electric power or mechanical horsepower.

It is a further objective of this invention to provide the means by which the power cogeneration method system's presented ~~alternate~~ alternative apparatus devices can comprise unconventional individual power train unit components that can be adapted to individual unit power generator ratings of 200 kW to 30 MW+ to satisfy most cogeneration facilities' installed individual unit power rating requirements.

It is a further objective of this invention to provide the collective means by which deviations from the presented invention's example operating conditions can be made to best accommodate a facility designer's incorporation of existing models of other facility auxiliary equipment that can be further incorporated into a specific design of cogeneration facility, said other auxiliary equipment comprising such as currently manufactured absorption chillers or mechanically-driven refrigeration chillers that have been conventionally or similarly applied in related waste heat recovery power facilities for over 30 years.

It is a further objective of the present invention's cogeneration method system and apparatus ~~means~~ devices to accomplish both a highly accelerated oxy-fuel combustion process and the added ~~means~~ capabilities to separately control both a preset maximum primary combustion zone temperature and the tertiary zone exhaust gases temperature supplied to the example gas turbine engine unit's hot gas expansion turbine assembly. This satisfied objective eliminates the elements of time and high degree of temperature that is required for endothermic dissociation chemical reactions to occur that produces both NO.sub.x and CO within the conventional air-fuel combustion product gases.

It is a further objective of the present invention of improved system method and apparatus ~~means~~ devices that ~~an AFE power system~~ the example modified conventional gas turbine power engine unit assembly or alternative unconventional re-configured turbine engine train apparatus assembly can be capable of achieving an additional 35% to 40% in ~~system~~ method thermal efficiencies than are available in current art B.A.T. gas turbine engine-powered ~~power~~ cogeneration facilities.

It is a further objective of the present invention of improved ~~system~~ power cogeneration method and apparatus ~~means~~ assembly devices, that the cited

~~incorporated partial-open~~ example gas turbine ~~cycle system~~ power engine unit and apparatus assemblies ~~means~~ of preferred high efficiencies can employ (but not limited to) gas compression ratios of 2.4 to 6.4 (2.1 to 6.5 Bar operating pressure). These said gas compression ratios ~~as~~ can be compared to conventional gas ~~turbines~~ turbine engines having varied employed compression ratios of approximately 9 to 35.

It is a further objective of the present invention of improved power cogeneration method system and apparatus ~~means~~ assemblies that the cited combined gaseous thermal fluid energy cycle, apparatus assemblies, and example gas turbine ~~cycle system~~ power engine unit ~~partial-open gas turbine cycle system and apparatus~~ can provide the maximum cogeneration thermal efficiencies with facility fuel gas supply pressures of less 100 psig (6.9 bar).

It is a further objective of this invention to provide the means wherein, during a steady-state power cogeneration operation, that the 'open portion' of the cited 'partially-open' gaseous thermal fluid energy cycle therein provide an approximate ~~atmospheric vented and open cycle portion of the cogeneration system cited exhaust~~ atmospheric-vented gas mass flow that can be approximately 5 to 8% of the total working motive fluid mass flow rate as contained within the 'closed portion' of the cited gaseous thermal fluid energy cycle ~~its turbine power cogeneration system~~.

It is a further objective of this invention to provide the method means whereby ~~both the cited partial-open AES gas turbine cycle system and~~ all apparatus assemblies and devices ~~as applied within the present invention of improved cogeneration system efficiency, and the alternative cogeneration system apparatus means described herein,~~ can collectively include appropriate safety sensor/transmitter and ~~system~~ gaseous thermal fluid flow control ~~device means~~ devices. ~~Both the~~ The presented invention's

power cogeneration system thermal fluid cycle streams, streams of supplied fuel and predominant oxygen, and contained apparatus ~~component means~~ assembly devices ~~and the separately associated cogeneration power plant auxiliaries~~ can be monitored and controlled for safe operation, ~~as well as having provided means for controlling the cogeneration system's individual system fluid flows in response to changes~~ during all cogeneration facility operations encompassing variations in electric power generation demands and ~~effective~~ thermal fluid heat energy extraction demands ~~by~~ from remote supplied steams of steam or hot water, or process fluids.

It is a further objective of this invention to provide the combination of power cogeneration method, apparatus assembly and control devices ~~means~~ by which a non-distribution quality of gaseous hydrocarbon fuel (containing toxic and/or difficult to combust hydrocarbon molecular gases) can be rapidly carried-forth through oxy-fuel combustion to a useful heat energy conversion and/or completed incineration without emitted toxic gas emissions to atmosphere.

The following nine embodiments comprise the subject matter of this invention:

First Embodiment

The working motive fluid of this invention's ~~turbine~~ power cogeneration method system comprises a continuous superheated vapor mixture of predominant carbon dioxide (CO.sub.2) and water vapor (H.sub.2 O) in identical Mol percent ratio proportions as the molecular combustion product components Mol percent ratio proportions are produced from the combustion of the gaseous or liquid hydrocarbon employed fuel.

Within the predominately-closed portion of the presented invention's cited power cogeneration method's partially-open gaseous thermal fluid energy cycle, ~~cogeneration~~

~~system and apparatus~~, the re-circulated power engine unit exhaust gas is routed from an exhaust gas distribution manifold (the exhaust gas having a small degree of superheat temperature and positive gage pressure supply) into the inlet of the ~~primary~~ recycle gas compressor. The exhaust gas recycle compression function can be performed by a more typical axial compressor section used for air compression within a conventional gas turbine power engine unit, or it may be a separately ~~means~~ power driver device-driven compressor of the axial, centrifugal, or rotating positive displacement type. Either ~~means~~ described type of compression can incorporate means of flow control available within the compressor or by its driver's varied speed, with flow changes being initiated by a ~~master system~~ power cogeneration PLC type control panel containing programmable logic microprocessors.

The cited type of compressor can increase the ~~recycled~~ example gas turbine power engine unit's recycled or recirculated exhaust's absolute pressure by a ratio range of only 2.4 to 6.4 to achieve a ~~preferred~~ relatively high example gas turbine power engine unit "stand-alone" simple-cycle thermal efficiency, but the in the case of the said gas turbine power engine unit's incorporation into the ~~cycle~~ invention's cited combined power cogeneration method and apparatus assembly devices, the gas turbine power engine unit is not limited to operations within these said ratios.

As shown in Table 1, between the example gas turbine engine unit's fuel combustion pressures of 45 psia and 75 psia, the ~~AES Cycle~~ cited gas turbine power engine unit's "stand-alone" simple-cycle thermal efficiencies can range between 35.16% and 43.24%. Between 75 psia and 90 psia oxy-fuel combustion burner assembly pressures (with the common individual ~~primary~~ recycle compressor and hot gas expander power turbine assembly efficiencies of 84%, and a stage 1 turbine inlet

temperature of 1800° F), the ~~AES turbine cycle system~~ cited gas turbine engine power unit "stand-alone" (simple-cycle) efficiencies can begin ~~begins~~ to decline.

TABLE 1

Combustion Operating Pressure	Gas Turbine Gas Inlet Temperature	Gas Turbine Exhaust Temperature	Gas Turbine Net Output Horsepower	Gas Turbine Fuel Rate Btu/HP-Hr.	Thermal Efficiency %*
45 psia	1800° F	1471° F	2859	7237	35.16
60 psia	1800° F	1391° F	3458	5983	42.54
75 psia	1800° F	1331° F	3515	5885	43.24
90 psia	1800° F	1284° F	3406	6075	41.89

*With a 1 Mol/minute methane gas fuel rate

The re-cycled (or recirculated) and re-pressurized turbine exhaust gas (hereafter can be referred to as "~~primary~~ either recycle gas, or re-pressurized recycle gas" within the cited power cogeneration method's partially-open gaseous thermal fluid energy cycle) is discharged from the ~~primary~~ recycle gas compressor at an increased temperature and pressure through a conduit manifold containing both a side-branch connection and first and second parallel conduit end-branches flow-controlled streams. The conduit manifold side-branch supplied controlled low mass flow stream of ~~primary~~ recycle gas can be reduced in temperature within an air-cooled exchanger prior to the stream flow's entry into one or more preferred partial pre-mix subassembly contained within each oxy-fuel combustion ~~burner~~ chamber assembly or subassembly. Within each referred partial pre-mix assembly, the reduced temperature ~~primary~~ recycle gas stream can be homogenously pre-mix blended with the supply stream of predominant oxygen that is also is also supplied to the preferred partial pre-mix subassembly and/or pre-mix blended with the supply stream of fuel.

The ~~fore-said~~ fore-cited first and second parallel conduit end-branches flow-controlled streams having end-connectivity respectively to the inlets of first and second headers of the power turbine exhaust gas waste heat recovery unit (WHRU) exchanger of counter-current flow gas to gas heat exchange design. A predominate flow-controlled portion of the ~~power turbine's~~ example gas turbine power engine unit developed high temperature exhaust is flow-directed through ~~this~~ the cited WHRU exchanger for its heat transfer into the ~~primary~~ recycle gas stream that thereafter is downstream re-admitted into the oxy-fuel fired combustion ~~burner~~ chamber assembly.

This ~~power turbine~~ example gas turbine power engine unit exhaust gas WHRU exchanger can be capable, with the particular example of a methane fuel combustion chamber pressure of 60 psi absolute and 1800° F first stage hot gas expansion power turbine inlet temperature, of raising the temperature of the ~~primary~~ re-pressurized recycle gas within the turbine exhaust gas WHRU exchanger to an approximate maximum 1350° F temperature. With these operating conditions and assumed individual compressor and hot gas expansion turbine efficiencies of 84%, ~~a desired simple-cycle turbine~~ the example gas turbine engine unit "stand-alone" simple-cycle thermal efficiency of 42.5% can be achieved.

Thereafter, the 1350° F highly superheated and re-pressurized ~~primary~~ recycle gas individual streams (and/or higher temperature method cycle fluid streams) ~~are~~ can hereafter be referred to as "working motive fluid" gas streams. The first controlled stream of working motive fluid can be routed and separately flow-divided as required to the internal tertiary blending zone contained within each of one or more oxy-fuel combustion ~~burner~~ chamber assembly or subassembly that can be conventionally positioned radially about the centerline axis of the ~~power turbine unit assembly~~ example

gas turbine power engine unit. The second controlled stream can be separately flow-divided as required for passage into one or more preferred partial premix sub-assemblies contained within one or more oxy-fuel combustion ~~burner~~ chamber assembly.

Within the presented power cogeneration system method, a lesser flow controlled portion of the total ~~power turbine~~ example gas turbine power engine unit's discharged exhaust flows through the waste heat recovery steam generator (WHRSG) exchanger or waste heat recovery process fluid (WHRPF) exchanger.

Second Embodiment

From the First Embodiment's "the re-circulated ~~turbine~~ power engine unit exhaust gas is routed from a exhaust gas distribution manifold (the ~~turbine~~ exhaust gas having a small degree of superheat temperature and positive gage pressure supply) into the inlet of the ~~primary~~ recycle gas compressor", the said re-circulated ~~turbine~~ power engine unit exhaust gas within the exhaust distribution manifold comprises the discharge exhaust gas from a second WHRSG or WHRPF exchanger upstream that is inlet-connected to a re-circulated exhaust gas manifold that conveys the combined example gas turbine power engine unit's reduced temperature exhaust gases originating from both the WHRU exchanger and the first parallel-positioned WHRSG or WHRPF exchanger into which the total example gas turbine power engine unit's high temperature exhaust is first inlet-connected.

Either the second WHRSG or second WHRPF exchanger can perform the initial heating of supplied streams from either a facility's steam or hot water feed circuit or a process fluid stream prior to either of these streams being further downstream flow-

connected to the fore-described high temperature example gas turbine power engine unit exhaust gases first WHRSG exchanger or WHRPF exchanger.

Third Embodiment

From the First Embodiment cited re-circulated example turbine power engine unit exhaust from the exhaust gas distribution manifold supplied to the inlet of the primary recycle gas compressor, the exhaust gas distribution manifold has a end manifold alternative system connection point and two side-branch flow delivery connections. The first side-branch conduit provides the greatly predominant flow of re-circulated exhaust gas into the inlet of the recycle gas compressor, and the second side-branch conduit directs the controlled flow of excess of re-circulated turbine exhaust gases to atmosphere during steady-state operation of the presented system. This flow of excess cited re-circulated turbine exhaust gases to atmosphere constitutes the "Open Portion" of the presented partial-open power cogeneration method system. The system steady-state condition's controlled mass flow rate, in which the re-circulated turbine exhaust is vented to atmosphere, is equivalent to the combined mass rates at which the fuel and the predominant oxygen gas streams enter the invention's provided oxy-fuel combustion system method's partially-open cycle and apparatus ~~means~~ devices.

Fourth Embodiment

From the First Embodiment cited "The second controlled stream can be separately flow-divided as required for passage into one or more preferred partial pre-mix sub-assemblies contained within one or more oxy-fuel combustion ~~burner~~ chamber assembly.", each partial pre-mix sub-assembly having the following introduced controlled streams: fuel; a predominant oxygen stream which originates from an adjacent facility area containing a preferred highly electric energy efficient modular air

separation system; First Embodiment described air-cooled ~~primary~~ recycle gas; and second stream of working motive fluid. These individual flow controlled conduit streams ~~at differential pressures and velocities~~ are collectively admitted through their respective pre-mixer inlet conduit means for preferred selective pre-mixing and homogeneous blending at points of admittance into the primary combustion flame zone and outer secondary zone within each oxy-fuel combustion ~~burner~~ chamber assembly.

To establish primary combustion temperatures that do not exceed the example preferred maximum 2400 F, one of several possible acceptable designs of pre-mix sub-assembly can be one of wherein the oxy-fuel combustion ~~burner~~ chamber assembly (a specific method or design of which is not within the scope of the presented invention) can incorporate both a primary oxy-fuel combustion flame zone and a secondary outer zone wherein a predominant portion of the fore-described second stream of working motive fluid is introduced into a outermost flow annulus area surrounding the homogeneous mixture admitted from each pre-mix sub-assembly into the said primary combustion flame zone for ignition. The secondary outer zone introduced working motive fluid can thereby provide a closely positioned rapid heat-absorbing greater mass shrouding means around each primary combustion flame zone developed within the oxy-fuel ~~burner~~ combustion chamber assembly. This flame shrouding means can enable the radiant heat energy emanating from the lesser mass binary gas molecules within the combustion flame to be rapidly distributed to and absorbed uniformly by the described shroud's contained greater mass of identical binary gaseous molecules at the speed of light rate of 186,000 miles per second. The resulting equilibrium temperature within each oxy-fuel ~~burner~~ combustion chamber assembly's primary combustion flame zone and secondary zone, based on the

controlled flow rate of the second stream of working motive fluid into the oxy-fuel combustion ~~burner~~ chamber assembly, can be established as being equal to a preset desired example of a maximum 2400° F or other desired preset temperature that is substantially less than the temperature at which ~~NO.Sub.x~~ NO,sub.x and CO can be formed during endothermic disassociation chemical reactions. The example maximum 2400° F merely represents a conservative maximum temperature to totally avoid the slightest potential of any combined production of extremely small trace amounts of NO.sub.x and companion larger amounts of CO.

Fifth Embodiment

From the First Embodiment cited "The first controlled stream of working motive fluid can be routed and separately flow-divided as required to the internal tertiary blending zone contained within each of one or more oxy-fuel combustion ~~burner~~ chamber assembly or subassembly that can be conventionally positioned radially about the centerline axis of the ~~power turbine unit assembly~~ example gas turbine power engine unit", the first controlled stream of working motive fluid to the tertiary blending zone flow can be introduced into an oxy-fuel combustion ~~burner~~ chamber assembly's inner annulus area between the ~~burner~~ chamber assembly's outer casing and an inner liner surrounding each primary oxy-fuel combustion flame zone and outer secondary zone, followed by its flow emanation into the ~~burner~~ chamber assembly's downstream-positioned tertiary blending zone chamber area through openings in the said inner liner. This tertiary zone introduced mass flow of superheated working motive fluid (of example 1350°F temperature) blends with the example maximum 2400° F equilibrium temperature combined gases emanating from the ~~burner~~ chamber assembly's primary oxy-fuel combustion flame zone and its outer secondary zone to thereby produce a

resultant example 1800° F final oxy-fuel ~~burner~~ combustion chamber assembly exhaust equilibrium temperature to the hot gas expansion turbine assembly. The equilibrium temperature of the final oxy-fuel ~~burner~~ combustion chamber assembly exhaust gases is not limited to 1800° F, and can be controlled by the introduced tertiary working motive fluid mass flow rate and/or fuel mass flow rate to establish any other higher or lower selected operating temperature. The example 1800°F temperature can be chosen to coincide with 10 year old proven power turbine blade metallurgy technology for continuous operation.

Within the one or more hot gas expansion turbine stages, the oxy-fuel combustion ~~burner~~ chamber assembly's pressurized and highly superheated gases are expanded to create useful work in the conventional form of both turbine power engine unit output shaft horsepower and (in the case of a conventional modified gas turbine power engine unit configuration) internal horsepower to additionally direct-drive the ~~primary~~ recycle gas compressor. In a conventional 2-shaft style of gas turbine engine configuration, the ~~primary~~ recycle gas compressor ~~is~~ can be shaft-connected to the high-pressure stage section of the power turbine assembly, and the low pressure section of the power turbine engine assembly with connected output shaft therein provides the turbine power assembly output power to driven equipment. The expanded exhaust gases exit the power turbine assembly at a low positive gage pressure and are further conveyed through conduit means to the fore-described WHRU exchanger and adjacent parallel-position WHRSG or WHRPF exchanger as further described later and shown in Figure1.

Sixth Embodiment

In the Fifth Embodiment description "In a conventional 2-shaft style of gas turbine engine configuration, the ~~primary~~ recycle gas compressor ~~is~~ can be shaft-connected to the high-pressure stage section of the power turbine assembly, and the low pressure section of the power turbine engine assembly with connected output shaft therein provides the turbine power assembly output power to driven equipment.", the presented invention provides an alternative system method and apparatus ~~means~~ devices by which an unconventional turbine power engine unit train (comprising individual separate compressor unit assembly, oxy-fuel combustion ~~burner~~ chamber assembly, and hot gas expansion turbine assembly unit with mechanical shaft output) can be configured to produce mechanical or electrical power within a cogeneration method system as described later and shown in Figure 2.

The invention's alternative ~~primary~~ recycle gas compressor can be a separately motor-driven or stream turbine-driven compressor of centrifugal or axial type therein comprising one or more stages of compression as required, or single rotating positive displacement type compressor for the system applied operating conditions. The re-circulated and slightly superheated turbine exhaust gas stream is re-introduced into the ~~primary~~ recycle gas compressor and increased in pressure and temperature as described for the conventional gas turbine power system. This presented style of ~~primary~~ recycle gas compression drive train generally offers greatly improved capacity control and/or turn-down capabilities, but can be overall less efficient than the conventional type gas turbine assembly's direct-driven axial compressor section.

As described in the Fourth and Fifth Embodiment, the oxy-fuel combustion ~~burner~~ chamber assembly configuration and functional operation remains unchanged. Rather

than the Fifth Embodiment described one or more oxy-fuel combustion ~~burner~~ chamber assembly being conventionally positioned radially about the centerline axis of the ~~power turbine unit assembly~~ example gas turbine engine unit, the presented invention's alternative system and apparatus means can further have a single oxy-fuel combustion ~~burner~~ chamber assembly that is axially centerline-positioned and can be directed-connected to the hot gas expander power turbine as shown later in Figure 2. ~~A single oxy-fuel combustion burner assembly can comprise multiple elements of existing manufactured oxy-fuel burner nozzle models rated from 0.6 to 14 MM Btu/Hr. as typically employed in the glass and steel making industries., or can comprise modifications to existing single industrial steam generation or process heater burner models that can be rated between 25 to 500 MM Btu/Hr.~~

Seventh Embodiment

From the Second Embodiment's cited "~~.....~~ the said re-circulated ~~turbine~~ power engine unit exhaust gas within the exhaust distribution manifold comprises the discharge exhaust gas from a second WHRSG or WHRPF exchanger upstream that is inlet-connected to a re-circulated exhaust gas manifold that conveys the combined example gas turbine power engine unit's reduced temperature exhaust gases originating from both the WHRU exchanger and the first parallel-positioned WHRSG or WHRPF exchanger into which the total example gas turbine power engine unit's high temperature exhaust is first connected.", the total amount of exhaust waste heat that can usefully be transferred into the said heat exchanger's supplied fluids is limited to (or in proportion to) the amount of ~~turbine~~ mechanical output power that is developed by the invention's power cogeneration system method employed power engine unit ~~turbine unit~~.

The presented invention provides an alternative method system and apparatus ~~means~~ devices by which ~~a~~ the presented power ~~turbine~~ cogeneration ~~system's~~ method's production of steam or hot water (or heating of process fluids) is independent of the amount of ~~turbine~~ power engine unit developed mechanical power ~~within a cogeneration system~~. This presented invention, with its described alternative method system and apparatus ~~means~~ devices, provides this power cogeneration method with added operational flexibility while further increasing the thermal efficiency of the presented invention's cogeneration method and maintaining the same ultra-low exhaust emissions. Wherein ~~a~~ an example presented given power cogeneration system facility of a given mechanical power output rating could fully utilize at all times a 100% or greater steam production or process fluid heating than would be associated with the cogeneration method system and apparatus ~~means~~ devices shown in Fig. 1, the Fig. 2 presented alternative cogeneration system and apparatus ~~means~~ devices can include the presented supplementary oxy-fuel fired heating of a selected portion of combined apparatus generated ~~recycled~~ recirculated system exhaust gases to achieve both the generated power and the additional production of steam or process fluid heating. The Fig.2 described alternative method system and apparatus ~~while~~ provides the device means of achieving the presented overall cogeneration system thermal efficiencies that can significantly exceed 115% as shown later in Table 5 for an example 100% increase in steam or process heating beyond the Fig. 1 system capabilities~~)~~.

The presented invention's alternative method system and apparatus ~~means~~ assembly devices includes the added conduit means for withdrawal of a portion of recited combined re-circulated ~~turbine~~ exhaust ~~gas~~ gases from the Third Embodiment described exhaust gas distribution manifold ~~for.~~ The said conduit provides a routed

supply of the re-circulated ~~turbine~~ exhaust gases to the example Fig.2 preferred two parallel auxiliary primary recycle blowers that are separately capacity controlled to produce slightly re-pressurized first and second conduit stream flows of exhaust recycled gas that are connected to the alternative cogeneration system's auxiliary oxy-fuel fired combustion burner assembly unit.

The cited oxy-fuel fired combustion burner assembly employs additional individual connected flow controlled streams of fuel and predominant oxygen to produce an identical composition of additional combustion exhaust gases as existing within the example gas turbine power engine unit's exhaust gases, whereby the said ~~added~~ additional oxy-fuel fired combustion burner assembly's exhaust gases are conduit routed into the turbine exhaust conduit branch connecting to the WHRSG exchanger or WHRPG exchanger described above in the above cited Second Embodiment ~~text~~.

In the case of the Fig. 1 configuration of the presented invention's power cogeneration method system and apparatus ~~means~~ assembly devices, any increase in power generation (beyond the then existing cogeneration system's 'steady-state' production condition, but not exceeding the example presented gas turbine's power engine unit output continuous rating), can be accomplished by terminating the controlled flow of vented excess turbine re-circulated exhaust flow to atmosphere and increasing the fuel flow and predominant oxygen gas flow. Only upon reaching the required accumulated increased mass flow of preset high temperature exhaust gases within the closed system, ~~is~~ shall the presented invention's power cogeneration method system then be returned to its normal 'steady-state' and 'partially-open system status' with controlled excess re-circulated exhaust gas vented to atmosphere.

Eighth Embodiment

From the First Embodiment cited "As shown in Table 1, between the example gas turbine power engine unit's fuel combustion pressures of 45 psia and 75 psia, the ~~AES Cycle~~ cited gas turbine power engine unit's "stand-alone" simple-cycle thermal efficiencies can range between 35.16% and 43.24%." The invention's improved high thermal efficient power cogeneration method 's presented example 60 psia oxy-fuel combustion chamber assembly therein enables a low fuel supply pressure of less than 65 psi gage (5,5 Bar) to be employed.

Ninth Embodiment

From the preceding collective Embodiments' cited control of fluid stream flows, temperatures, pressures, generated power, and apparatus means includes valves, compressors, blowers, motors, etc., the presented invention's power cogeneration method system and apparatus means can be both performance and safety monitored and controlled by a manufacturer's PLC based control panel design that meets or exceeds the power cogeneration facility's applicable industry and governmental standards and codes, and as is applicable to the power cogeneration method's specifically employed apparatus assembly devices. ~~American Petroleum Institute (API) specifications for industrial gas turbines (API 616) or aero-derivative gas turbines specification (API RP 11PGT), or API 617 for centrifugal compressors (and applicable portions therein to be applied to hot gas expanders), or API 619 for rotary positive displacement compressors, or API 673 for special fans, or added safety monitoring as required within API 560 for fired heaters for general refinery service, or NFPA 85C for prevention of boiler and furnace explosions, and can be further control integrated with a power plant distributive control system (DCS). The PLC based control panel design can~~

~~further comply with other prevailing commercial, industrial or other governmental jurisdiction codes and standards. Other cogeneration plant individual auxiliary support system modular component PLC control panel's operating output data signals can be control-integrated into the DCS together with the~~ . The operating power cogeneration method ~~power~~ system's operating data signals can comprise, ~~comprising~~ but not limited to:

(a) the power cogeneration method system's apparatus connecting conduits containing individual valve controlled gas stream's mass flows with temperatures and pressures for a given operating hydrocarbon fuel composition and horsepower or kilowatt output, and effective waste heat transfer duty;

(b) the power cogeneration method system's power ~~turbine~~ engine unit exhaust and waste heat recovery unit's fluid conditioning status and ~~turbine~~ power engine unit exhaust excess oxygen content for a given operating hydrocarbon fuel composition;

(c) the power cogeneration method system's power engine unit ~~turbine~~ exhaust and ~~primary~~ recycle gas compressor discharge mass flow rates through their respective downstream waste heat recovery exchangers;

(d) the power cogeneration method facility's auxiliary rotating equipment's operating mass flow rates with temperatures and pressures combined with the positioning-state of any rotating equipment's integral capacity control apparatus;

(e) the power cogeneration method facility's rotating equipment and alternative blower/oxy-fuel fired ~~heater~~ combustion burner assembly safety monitoring condition point locations as set forth by the prevailing industry or government specifications for each type of equipment, as well as those monitoring points whose operating condition

state can impact on the power cogeneration method apparatus assembly device's ~~system's~~ operational on-line availability and equipment life cycle costs.

Overall System Method and Apparatus Means

Within the presented ~~partially-open turbine~~ improved power cogeneration system method and apparatus ~~means~~ assembly devices described herein, the provided system employed oxy-fuel combustion generated working motive fluid means can provide a 95 to 100% reduction of nitrogen oxides (NO.sub.x) that occurs within current art Low-NO.sub.x ~~gas turbines~~ employed type of power engine units. The ~~provided~~ partially-open ~~turbine~~ gaseous thermal fluid energy cycle contained within the cited power cogeneration method's provides a temperature controlled oxy-fuel combustion temperature and the speed of combustion flame heat transfer that also similarly suppresses the chemical reaction dissociation formation of the fugitive emission carbon monoxide (CO) from carbon dioxide (CO.sub.2). The means of suppressing the development of fugitive emissions results from the following collective working motive fluid molecular attributes and combustion events:

(a) The working motive fluid of this invention's power cogeneration method system and apparatus devices comprises a continuous superheated mixture of predominant carbon dioxide (CO.sub.2) and water vapor (H.sub.2 O) in identical Mol percent ratio proportions as these molecular components are produced from the combustion of a given fuel. For example, in the case of landfill gas, the working gas fluid contains a 1:1 ratio of 2 Mol carbon dioxide to 2 Mols water vapor in identical proportion to the products of stoichiometric oxygen combustion. The chemical reaction equation can be described as follows:

Working Motive Fluid + 1 Mol CH.sub.4 + 1 Mol CO.sub.2 + 2 Mols O.sub.2 = 2 Mol CO.sub.2 + 2 Mol H.sub.2 O + Heat + Working Motive Fluid.

In the example of methane gas fuels, the working fluid composition contains a ratio of 1 Mol CO.sub.2 to 2 Mols H.sub.2 O in identical proportion to the products of 105% stoichiometric oxygen combustion of methane fuel within the chemical reaction equation of:

Working Motive Fluid + 1 Mol CH.sub.4 + 2.1 Mols O.sub.2 = 1 Mol CO.sub.2 + 2 Mols H.sub.2 O + 0.1 Mol O.sub.2 + Heat + Working Motive Fluid;

(b) The invention's ~~turbine~~ power cogeneration system's method's working fluid provides the replacement mass flow means to ~~the~~ conventional open ~~Brayton simple~~ power ~~cycle's~~ cycles incorporating the predominant diatomic non-emissive and non-radiant energy absorbing molecular component nitrogen (N.sub.2) within the cited conventional cycles working motive fluid. The invention's replacement working motive fluid contains both predominant water vapor (with a binary lack of molecular symmetry) and a mass ratio of atomic weights of (16/2) = 8 and carbon dioxide with a mass ratio of atomic weights of (32/12) = 2.66, which denotes their susceptibility to high radiant energy emissivity and absorption. This compares to the nitrogen's mass ratio 14/14 = 1 which denotes nitrogen's minimal, if any, emissive and radiant energy absorbing abilities at any temperature;

(c) The presented invention's ~~turbine~~ power cogeneration method's cycle system's controlled flow of working motive fluid ~~provides~~ into the oxy-fuel combustion chamber assembly therein provides the said assembly's interior gaseous environment ~~means for turbine combustion chemistry~~ with an approximate 900 % increase of binary molecular mass means susceptible to the fuel/oxidation exothermic chemical reactions generated

~~heat of~~ combustion heat transfer being highly accelerated at the speed of light (186,000 miles a second). The cited highly accelerated rate of combustion heat transfer to the highly predominant interior binary gases within the cited combustion apparatus assembly, provides the means by which a controlled highly superheated temperature equilibrium state of accelerated fuel and oxygen reaction rates is maintained without the prospect of developing CO2 disassociation reactions that produces CO in the presence of the highly elevated gas molecular temperatures above 2600° F to 2900° F;

The cited binary gases being comprised of individual binary carbon dioxide and binary water vapor molecular gases whose individual molecular mass heat energies are separately emitted or adsorbed in their own individual and specific narrow and unique infrared spectral ranges. ~~This enables the complete and rapid combustion of gaseous or liquid hydrocarbon fuels through the absorption and emissive radiant heat transfer of the fuels' combustion product's highly superheated binary carbon dioxide and binary water vapor molecules' heat energy that is emitted in their individual infrared spectral ranges~~.

The radiant heat is transferred from the cited binary carbon dioxide and binary water vapor combustion gaseous products in their specific Mol% proportions as determined by the molecular fuel being combusted, the said gaseous Mol% proportions being sustained throughout the gaseous thermal fluid energy cycle, including the working motive fluid that enters the fuel combustion chamber assembly device along with supplied fuel and oxygen. ~~The radiant heat is transferred by radiant energy absorption into the combined greater mass identical proportions of identical composition gases contained within the working motive fluid blended within the pre-combustion gases and more predominantly contained in the outer secondary zone surrounding the primary~~

~~combustion flame zone. The extremely rapid rate at which the combustion product gases are lowered in temperature, means there is inadequate time for the chemical disassociation reactions to occur, which produce carbon monoxide (CO), or other chemical reactions which produce nitrogen dioxide (NO.sub.2), in the presence of the highly elevated gas molecular temperatures above 2600° F to 2900° F;~~

(d) The First Embodiment recited oxy-fuel combustion ~~burner~~ <u>chamber</u> assembly pre-mix sub-assemblies provides the means for homogeneous blending, wherein gaseous streams of working motive fluid and an oxygen-rich stream ~~are~~ <u>can be</u> further homogeneously blended for downstream mixing and ignition with the gaseous fuel stream. The gaseous fuel stream also comprises binary molecules of high susceptibility to high radiant energy absorption and emissivity, such as methane with a mass ratio of atomic weights of (16/4) = 4, ethane with a mass ratio of atomic weights of (24/4) = 6, propane with a mass ratio of atomic weights of (36/8) = 4.5, etc;

(e) The subsequent tertiary zone admission of a controlled-flow of Table 1 identified 1350° F superheated working motive fluid into the example 2400° F. ~~burner~~ <u>combustion chamber</u> assembly's primary oxy-fuel combined primary combustion flame zone and its outer secondary zone combustion gas stream, results in the rapid creation of the example desired equilibrium temperature of 1800° F. This rapid establishment of the preferred equilibrium temperature is due to the 186,000 miles per second rate of radiant heat transfer between the two streams of common molecular constituents with common means of high radiant energy absorption and emissivity in their respective individual infra-red spectrum ranges.

The presented <u>improved power</u> cogeneration <u>method and apparatus devices employ a partially-open gaseous thermal fluid energy cycle therein incorporating an</u>

~~power system's~~ oxy-fuel fired combustion system's apparatus assembly generated working motive fluid gases of optimum selected operating pressures and temperatures that can achieve 115% or greater power cogeneration ~~system~~ facility thermal efficiencies. The means of achieving these 40% to 50% increased thermal efficiencies than those thermal efficiencies provided by current art conventional cogeneration power facilities (thereby reducing CO.sub.2 "greenhouse mass flow emissions" by ~~30% to 33%~~ 40% to 50%), results from the following improved power generation method and apparatus devices, employed partially-open gaseous thermal fluid energy cycle, and the collective working fluid molecular thermal characteristics or attributes comprising ~~system design, and apparatus features~~:

(a) The oxy-fuel combustion ~~burner~~ chamber assembly's low operating pressures reduces the work (per pound of primary recycled gas) that is adsorbed by the employed power engine unit's ~~turbine train's~~ compressor ~~section~~ apparatus assembly, the said compressor ~~that re-pressurizes~~ re-pressurizing the recycled power engine unit exhaust gas stream that subsequently becomes the downstream highly superheated working motive fluid that is expanded through the employed power engine unit's hot gas expansion ~~turbine~~ power output assembly;

(b) The presented improved power cogeneration method system working motive fluid molecular gas composition replaces air content nitrogen that is the predominant mass flow molecular gas component in ~~the~~ a conventional ~~gas turbine~~ internal combustion engine's working motive fluid. The presented improved power cogeneration method system working motive fluid is unique in that each highly superheated temperature pound of fluid can adsorb or exchange approximately 42% more heat per degree Fahrenheit change in gas temperature than does air or nitrogen.

(c) In the presented example operating conditions, approximately 92% of the high temperature example gas turbine power engine unit exhaust heat energy that is recovered from within the total exhaust flow passing through the WHRU exchanger and first WHRSG exchanger (or WHRPF exchanger) is transferred back into the ~~low pressure~~ pressurized working motive fluid that will re-enter the oxy-fuel combustion ~~burner~~ chamber assembly to further absorb the heat of fuel combustion.

(d) Approximately 92 to 95% of the presented improved power cogeneration method system's re-circulated exhaust downstream of the waste heat exhaust exchangers (therein still containing a large 'heat sink' quantity of energy) can approximately be recycled within the closed portion of the improved power cogeneration method system during steady-state operation. During an increased energy output demand on the presented power cogeneration method system, 100% of the presented improved cogeneration method system's re-circulated exhaust heat capacity downstream of the waste heat exhaust exchangers ~~is~~ can be recycled during its accompanying 'total-closed' cycle method system operation.

(e) The presented improved power cogeneration method system employed partially-open gaseous thermal fluid energy cycle, and the described operating characteristics of the continuous and uniform superheated gaseous heat transfer fluid, enables the presented power cogeneration method to annually maintain a continuous facility power output rating without any imposed site ambient temperature derations.

With the presented example ~~partially-open~~ turbine power engine unit ~~cycle power powered~~ cogeneration method system and apparatus ~~means~~ assembly devices described herein, or including the presented alternative system power cogeneration method and employed apparatus ~~means~~ assembly devices, either a modified

conventional gas turbine power engine unit ~~power~~ apparatus train or an unconventional turbine power engine unit train comprised of two or more apparatus assemblies can be employed. An alternative ~~AES~~ turbine power engine unit assembly ~~unit~~ apparatus configuration can utilize separate existing low cost mechanical equipment components and combustion chamber and burner assemblies which ~~are~~ can be predominantly not designed for, nor applied to, the manufacture of conventional gas ~~turbines~~ turbine power engines, nor the said components' incorporation into facility designs of current technology ~~gas turbine~~ power cogeneration facilities ~~systems~~.

Within the presented ~~partially-open turbine cycle~~ power cogeneration method system and apparatus ~~means~~ assembly devices described herein, the presented invention provides an alternative ~~system~~ improved power cogeneration method and apparatus ~~means~~ assembly devices by which a ~~turbine~~ power cogeneration~~-method~~ system's production rate of steam or hot water (or heating of process fluids) ~~is~~ can be independent of the actual percentage of full-rated mechanical or electric power load that is being produced from ~~an operating turbine powered~~ the described power cogeneration method system. The presented example alternative power cogeneration method system and apparatus ~~means~~ assembly devices is not limited in its ability to have expanded steam or hot water or process fluid heating capacity ~~means~~ capabilities beyond that which is possible solely from a power engine unit's ~~turbine~~ exhaust gas waste heat utilization.

Within the presented ~~partially-open turbine cycle~~ power cogeneration method system and apparatus ~~means~~ assembly devices described herein, the ~~system's and~~ apparatus assembly devices are provided wherein all fluid streams entering the oxy-fuel ~~fuel~~ combustion ~~burner~~ chamber assembly (and alternative combustion burner

assembly) are controlled to maintain preset maximum combined primary combustion flame zone and outer secondary zone temperatures in which a non-distribution quality of gaseous hydrocarbon fuel (containing toxic and/or difficult to combust hydrocarbon molecular gases) can be rapidly carried through the oxy-fuel combustion method to a useful heat conversion and/or completed incineration without significantly altering the method system's high thermal efficiencies or ultra-low emission levels.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a schematic flow diagram of the invention's improved power cogeneration method system and apparatus devices employed within a partially-open gaseous thermal fluid energy cycle therein incorporating ~~that includes the presented AES partially-open power cycle with a~~ an example modified configuration of a conventional gas turbine power engine unit and simplified waste heat transfer apparatus for either steam or hot water generation, or process fluid heating.

Fig.2 is a schematic flow diagram of the invention's improved cogeneration method system that includes the presented A~~ES partially-open power cycle system and apparatus~~ partially-open gaseous thermal fluid energy cycle of Fig. 1, and additional alternative example comprising a non-conventional turbine power engine unit and apparatus ~~means~~ assembly devices including an alternate separate motor or steam turbine driven recycle or recirculated exhaust gas compressor, an oxy-fuel combustion ~~burner~~ chamber assembly series-connected to a hot gas expander turbine device, and an alternative supplementary blower/oxy-fuel fired combustion burner assembly that ~~increases system~~ can sustain rated steam or hot water production or heating of process fluids irregardless of the said example non-conventional turbine power engine unit's output of mechanical or electric power.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now more particularly to Fig. 1, ~~a~~ an example modified conventional gas ~~turbine's~~ turbine engine power unit's exhaust recycle gas compressor section **1** comprises ~~2~~ two or more ~~recycled~~ recycle exhaust gas compression stages, positioned in series, with a final stage of radially directed discharge flow of compressed or re-pressurized recycle exhaust gas. In the case of a two-shaft turbine engine, the power to drive the recycle gas compressor section **1** is transmitted by shaft **2**, on which one or more high-pressure power extraction turbine stages are mounted within the combustion hot gas expansion power turbine assembly **3**. The second shaft, designed for mechanical equipment or generator drive applications, has one or more low-pressure hot gas expansion power stages mounted on power output shaft **4**, with coupling means for power transmission to rotate the driven equipment.

The invention's ~~cycle~~ improved power cogeneration method adaptation to modified conventional gas turbine engine driven mechanical equipment may or may not require the addition of a gearbox or variable speed coupling **5** to adapt the speed of the hot gas expansion power turbine assembly **3** to the speed required by a generator or other driven equipment (not shown). The rotating driven equipment may have its required power transmitted through a shaft and coupling ~~means~~ device **6**. The shaft and coupling means device **6** can transmit power to a generator **7**, wherein electric power is produced and transmitted through conduit means **8** to a control room module **9**. Control room module **9** therein can contain ~~contains~~ the ~~modular~~ turbine power engine unit's PLC control panel, ~~and~~ electrical switchgear, and motor control center, whereby electric power production is controlled and distributed to the power cogeneration

facility's electrical grid and/or connected electric utility electrical grid. The shaft and coupling ~~means~~ device **6** may alternately transmit power to other rotating pumps or compressors (not shown) in lieu of generator **7**.

Within the presented invention's ~~partially-open~~ improved power cogeneration system method, including a partially-open gaseous thermal fluid energy cycle and apparatus devices, the slightly superheated example turbine power engine unit's ~~exhaust~~ re-circulated exhaust gas flows from the ~~turbine~~ exhaust gas distribution manifold **10** (having end-connection **62** that is blind-flanged closed in this Figure 1) through said manifold side-branch connected ~~turbine~~ exhaust recycle gas conduit means **11** that is end-connected to the inlet of the ~~turbine exhaust gas primary~~ recycle gas compressor section **1**. The higher-pressure and higher-temperature compressed gas discharged from the recycle gas compressor section 1 ~~recycle turbine exhaust gas~~ (hereafter referred to as "~~primary~~ recycle gas, or re-pressurized recycle gas") is routed through conduit manifold **12** containing two parallel conduit end-branches **13** and **14** respectively, ~~each~~ either one or both said conduit branch therein containing a gas mass flow sensor means and a flow control (or flow proportioning) damper valve **15**.

The twin parallel conduit end-branches **13** and **14** respectively convey first and second primary re-pressurized recycle gas streams with respective end connections to parallel inlet headers **16** and **17** located on the ~~primary~~ section **18** of the example ~~power~~ turbine power engine unit's exhaust gas waste heat recovery unit (WHRU) exchanger. The said first and second streams of ~~primary~~ re-pressurized recycle gas is discharged from ~~primary~~ section **18** of the ~~power~~ cited turbine power engine unit's ~~exhaust gas waste heat recovery unit (~~WHRU~~)~~ exchanger through outlet headers **20** and **19** respectively at highly increased superheated temperatures (with the highly superheated

recycle gas hereinafter referred to as a "working motive fluid") with flows through conduits **21** and **22** respectively.

The ~~primary~~ re-pressurized recycle gas ~~is~~ additionally can be routed at low gas flow levels from conduit manifold means **12** through a side-branch connected conduit means **23** containing motor driven air-cooler **24** and flow control valve **25** for subsequent downstream conduit end-connection to one or more partial premix sub-assemblies **27** that can be contained within one or more oxy-fuel combustion ~~burner~~ chamber assembly **26**, the said assembly may therein ~~that can be~~ preferably be conventionally positioned radially about the centerline axis of the cited ~~power~~ turbine power engine unit assembly.

Conduit **22** conveys the second controlled stream of working motive fluid to the internal primary combustion zone **28** contained within each oxy-fuel combustion ~~burner~~ chamber assembly **26.** Conduit **21** conveys the first controlled stream of working motive fluid to the internal tertiary blending zone **29** contained within each oxy-fuel combustion ~~burner~~ chamber assembly **26** that can be positioned radially about the centerline axis of the turbine assembly. The combined streams of working motive fluid composition gases exiting tertiary blending zone **29** can be routed through conduit flow means **30** having end connection to the inlet of the hot gas expansion power turbine assembly **3.**

Alternately the conduit **21** can convey the first controlled stream of working motive fluid to a common single tertiary blending zone that receives primary combustion zone working fluid composition gases from two or more oxy-fuel combustion ~~burner~~ chamber assembly **26** that is positioned immediately upstream of the described alternate single common (not shown) tertiary blending zone. The combined streams of working motive

fluid composition gases exiting the common tertiary blending zone (not shown) are routed through conduit **30** having end connection to the inlet of the hot gas expansion power turbine assembly **3**.

A pressurized stream of presented example methane fuel gas (or alternate acceptable liquid hydrocarbon fuel) is supplied from source **31** into conduit **32** ~~containing~~ that therein can contain sensor-transmitter ~~means~~ devices for temperature, pressure, mass flow, and a fuel flow control valve ~~means~~ device **33**, with said conduit having end-connectivity to either one or more preferred downstream partial pre-mix subassembly **27** contained within oxy-fuel fired combustion ~~burner~~ chamber assembly **26.**

A controlled pressurized stream of predominant oxygen gas is supplied from a facility remote source **34** into conduit **35** ~~containing~~ that may contain sensor-transmitter ~~means~~ devices for oxygen %, temperature, pressure, mass flow, and a flow control valve ~~means~~ device **36**, with said conduit having end-connectivity to either one or more preferred partial pre-mix subassembly **27** contained within oxy-fuel combustion ~~burner~~ chamber assembly **26.**

Within the partial pre-mix subassembly **27**, the said identified conduits **23**, **32**, and **35** respectively supplied controlled stream flows of ~~primary~~ re-pressurized recycle gas, fuel, and predominant oxygen are therein partially blended therein for following downstream ignition and controlled temperature combustion within the temperature sensor-transmitter monitored primary combustion zone **28** therein having further admitted second controlled stream of working motive fluid composition gases supplied by conduit **22.**

Within oxy-fuel fired combustion ~~burner~~ chamber assembly **26**, the combined mass ~~flows~~ flow of products of fuel combustion and streams of working motive fluid composition gases flows from the primary combustion zone **28** at a controlled highly superheated presented example equilibrium temperature of 2400F into the downstream positioned tertiary blending zone **29** wherein these said gases are blended with the controlled mass flow of fore-described conduit **21** supplied first stream of working motive fluid composition gases.

The combined working motive fluid composition gases' mass flows entering the tertiary blending zone **29** within oxy-fuel fired combustion ~~burner~~ chamber assembly **26**, Mixing together with primary combustion zone gases, therein produces a resultant selected equilibrium temperature and mass flow rate of superheated working motive fluid gases through conduit **30** into the hot gas ~~expander~~ expansion power turbine subassembly **3**. Work is developed within the hot gas ~~expander~~ expansion power turbine subassembly **3,** and the heat energy or enthalpy (Btu/lb) contained within the mass flow of expanded and exhausted working motive fluid gases is decreased and discharged into conduit **37**. Conduit **37** routes the hot gas ~~expander~~ expansion power turbine subassembly exhaust gases through conduit end-branches **38** and **41** that are respectively connected to WHRU exchanger **18** and waste heat recovery steam generator (WHRSG) or waste heat recovery process fluid heater (WHRPF) exchanger **42.** The proportional division of the total mass flow of the hot gas ~~expander~~ expansion power turbine subassembly **3** exhaust gas contained within conduit **37,** between conduit end-branches **38** and **41,** ~~is~~ can be flow-controlled or flow-proportioned respectively by damper valves **40** and **44** contained within the WHRU exchanger **18** and WHRSG or WHRPF exchanger **42** respective outlet exhaust branch conduits **39** and **43.** The

predominant portion of conduit **37**'s total mass flow of exhaust gases is divided and directed through WHRU exchanger **18** to satisfy the working motive fluid exhaust heat transfer requirements to the cited lower temperature ~~primary~~ re-pressurized ~~recycled~~ recycle gas flowing through exchanger **18**.

In the case of waste heat transfer to a power cogeneration facility's ~~facilities~~ supplied hot water/steam or process fluid circuit, a pressurized stream of a power cogeneration facility's steam condensate feed water (or process fluid) can be supplied from source **46** into conduit **47** that can therein contain sensor-transmitter ~~means~~ devices for both temperature and mass flow, and having end-connectivity to the inlet header **48** of a second ~~(~~WHRSG~~)~~ or WHRPF exchanger **49**. In the case of stream generation, the supplied stream of steam condensate can be changed from a liquid phase to a liquid/vapor 2-phase state or slight superheated steam vapor state within exchanger **49**, and exits from exchanger **49** through discharge header **50** into conduit **51** having end-connectivity to the inlet header **52** of the first WHRSG exchanger **42**. Within WHRSG exchanger **42**, the steam circuit stream can be highly superheated as desired to provide a power cogeneration facility produced steam superheat temperature that can range ~~ranging~~ from less than 900ºF to over 1200ºF for discharge from outlet header **53** into conduit **54** end-connected to ~~that can deliver the superheated steam to a facility~~ delivery ~~connection~~ point **55.** For the alternative addition of ~~increased~~ the presented improved power cogeneration method's system having increased or independent mass flow steam generation (as described later in Figure 2), ~~expander~~ the hot gas expansion power turbine subassembly exhaust gas conduit **37**'s end-branch conduit **41** can be supplied with a connected side-branch conduct **56** whose end flange connection **57** ~~that is~~ can be closed with a blind-flange cover in Figure 1.

The presented power cogeneration method system's reduced temperature exhaust gases exits from the WHRU exchanger **18** and the parallel-positioned WHRSG exchanger or WHRPF exchanger **42** (as earlier recited) through their respective exhaust gas discharge branch conduits **39** and **43**, each branch conduit respectively therein ~~containing~~ can contain controlled-flow damper valves **40** and **44**. The reduced temperature ~~system~~ re-circulated exhaust gas flows from branch conduits **40** and **44** are combined within re-circulated exhaust gas manifold **45** having end-connectivity to a downstream-positioned second WHRSG exchanger or WHRPF exchanger **49.** The ~~system's~~ power cogeneration method's re-circulated exhaust gases are reduced in temperature within the second WHRSG exchanger or WHRPF exchanger **49** to a temperature that ~~is~~ can be slightly above the dew point temperature of the re-circulated exhaust gas as it is discharged from the heat exchanger **49** into the exhaust gas distribution manifold **10**.

Within the presented invention's power cogeneration method included partially-open gaseous thermal fluid energy cycle and apparatus devices ~~partially-open cogeneration power system~~, the slightly superheated example turbine power engine unit's re-circulated exhaust gas mass flow within exhaust gas distribution manifold **10** remains at a constant flow rate ~~for~~ during steady-state power cogeneration thermal energy conversion operations. ~~The~~ During the recited steady-state operation, the recited method's generated excess of slightly superheated ~~turbine~~ re-circulated exhaust gas mass flow within manifold **10** ~~that is not required for steady-state turbine power production~~, ~~is~~ can be flow-directed from manifold **10** through side-branch conduit **58** having downstream connectivity to atmosphere at vent point **61**, and said conduit may therein ~~containing~~ contain back pressure control valve **59** and flow control valve **60** ~~and~~

~~having downstream connectivity to atmosphere at vent point 61~~. The terminal end of exhaust gas distribution manifold ~~11~~ 10 is provided with a closed blind flange connection **62** in Fig.1.

Fig.2 is a schematic flow diagram of the invention's improved power cogeneration method system ~~that shows the same presented partially-open power turbine cycle system~~ as shown in Fig. 1, but ~~with~~ therein having ~~added~~ specifically ~~herein~~ added described alternative apparatus ~~means~~ assembly devices that can include both an alternate separate motor or steam turbine driven recycle gas compressor and ~~industrial-type~~ an oxy-fuel combustion ~~burner~~ chamber assembly that is series-connected to a separate hot gas ~~expander~~ expansion turbine ~~with~~ having an output power shaft ~~connection means~~. Fig.2 further shows ~~and describes~~ the ~~alternate system~~ power cogeneration method's included partially-open gaseous thermal fluid energy cycle and apparatus devices with the recited alternative addition of a separate oxy-fuel fired combustion burner assembly that performs the function of a supplementary hot exhaust gas generator ~~to~~ that can increase the power cogeneration system's method production of either steam, hot water, or the heating of process fluids.

Referring now more particularly to Fig. 2, the recited ~~presented invention's improved cogeneration system therein incorporates the AES partially-open power cycle system and alternative apparatus means that can include an~~ alternative separately driven ~~primary~~ recycle gas compressor **63** can comprise ~~comprising~~ two or more ~~power-system~~ recycle gas compression stages, with a final gas compression stage that can incorporate an outward radially-directed discharge flow of ~~primary~~ re-pressurized recycle gas. ~~Primary~~ The recycle gas compressor **63** can alternately be directly driven by either an electric motor or a steam turbine type driver **64**, or the said compressor

indirectly-driven through either gearbox or variable speed coupling ~~means~~ assembly device **65.** ~~The system's~~ The ~~cogeneration~~ recited hot gas expansion power turbine assembly **67** can comprise one or more power extraction turbine stages and an assembly output shaft that can be directly connected to electrical generator **7** wherein electric power is produced and transmitted through conduit means **8** to a control room module **9**. Control room module **9** therein contains the power cogeneration system's PLC control panel, and an electrical switchgear and motor control center which provides the means by which~~, whereby~~ electric power production can be controlled and distributed to the operating facility's electrical grid and/or to the utility electrical grid. Alternately (not shown), a gearbox or variable speed coupling can be positioned between the power turbine assembly output shaft and alternative driven rotating pumps or compressors (not shown) in lieu of generator **7**.

Referring now more particularly to Fig. 2 and the flows of thermal fluids within the partially-open gaseous thermal fluid energy cycle contained within the ~~Within the presented invention's partially-open~~ presented invention's power cogeneration method containing alternative apparatus assembly devices. ~~system of Fig.1, the~~ The slightly superheated ~~turbine~~ exhaust recycle gas can flow from the ~~turbine~~ exhaust gas distribution manifold **10** with exiting flows through open end-connection **62** that series-connects to manifold extension conduit **68** as further described later. Manifold **10** side-branch connected ~~turbine~~ exhaust recycle gas conduit means **11** is end-connected to the inlet of the ~~turbine~~ exhaust gas ~~primary~~ recycle gas compressor **63**. The higher-pressure and higher-temperature re-pressurized recycle ~~turbine~~ exhaust gas (hereafter referred to as "~~primary~~ re-pressurized recycle gas") and related identical stream flows are thereafter the same as described as in Fig.1 for its routing through WHRU **18** and

continuing to oxy-fuel fired combustion ~~burner~~ chamber assembly **26.** The ~~hot~~ highly superheated working fluid gases ~~generated within~~ emitted from the oxy-fuel ~~fired~~ combustion ~~burner~~ chamber assembly **26** are routed through direct-connected gas transition assembly **66** with end connectivity to the inlet of the hot gas expansion power turbine assembly **67**.

Conduit **37** routes the hot gas ~~expander~~ expansion turbine assembly **67** exhaust gases through conduit end-branches **38** and **41** that are respectively connected to ~~exhaust gas waste heat recovery unit (WHRU)~~ WHRU exchanger **18** and ~~waste heat recovery steam generator (~~WHRSG~~)~~ or WHRPF ~~process fluid heat~~ exchanger **42** and thereafter described associated conduit streams are as described for Fig.1. For the alternative addition of ~~increased~~ the power cogeneration method's developed generation of additional thermal heat for transfer to steam, hot water, or process streams ~~system mass flow steam generation~~, fore-described conduit **68** can route a flow of slightly superheated ~~turbine~~ exhaust recycle gas through preferred parallel end-branch conduits **69** and **70** that respectively ~~containing~~ can contain flow proportioning or flow control provided isolation/damper valves **71** and **72** and having end connectivity with one or more parallel-positioned **73** and **74** speed-controlled motor-driven exhaust recycle ~~exhaust~~ gas blowers. Exhaust recycle gas blower **73** provides a required mass flow of exhaust recycle gas at a slightly increased pressure into its discharge conduit **75** having end-connectivity with the tertiary blending zone **82** contained within the downstream-positioned oxy-fuel fired combustion burner assembly **79.** Exhaust recycle gas blower **74** provides a required mass flow of exhaust recycle gas at a slightly increased pressure into its discharge conduit **76** having end-connectivity with the partial

pre-mix subassembly **80** contained within the downstream-positioned oxy-fuel fired combustion burner assembly **79.**

A controlled stream of low pressure predominant oxygen gas mixture is supplied from facility remote source **77** into conduit **84** that can contain ~~containing~~ sensor-transmitter ~~means~~ for oxygen %, temperature, pressure, mass flow, and oxygen flow control valve ~~means~~ device **85**, with said conduit **84** having end-connectivity to either one or more preferred partial pre-mix subassembly **80** contained within oxy-fuel fired combustion burner assembly **79.**

A low pressure stream of presented example methane fuel gas (or alternate acceptable liquid hydrocarbon fuel) is supplied from source **78** into conduit **86** that can contain ~~containing~~ sensor-transmitter means for temperature, pressure, mass flow, and fuel pressure/flow control valve means **87**, with said conduit **86** having end–connectivity to either one or more downstream-positioned preferred partial-premix subassembly **80** contained within oxy-fuel fired combustion burner assembly **79.**

Within the partial pre-mix subassembly **80**, the said identified conduits **76**, **86**, and **84** respectively supplied stream flows of ~~turbine~~ exhaust recycle gas, fuel, and predominant oxygen gas mixture are therein blended for following downstream ignition and controlled temperature combustion within the temperature sensor-transmitter monitored primary combustion zone **81** contained within oxy-fuel fired combustion burner assembly **79.**

Within oxy-fuel fired combustion burner assembly **79**, the predominant mass flow of combined products of fuel combustion and ~~turbine~~ exhaust recycled gas flows from the primary combustion zone **81** (at a controlled high superheated presented example equilibrium temperature of 2400F) into the downstream tertiary blending zone **82**

wherein these said composition gases can be blended with the controlled mass flow of fore-described conduit **75** supplied blower discharge stream of slightly re-pressurized and low superheated ~~power turbine~~ exhaust recycle gases of identical molecular and Mol% gas composition.

The oxy-fuel fired combustion burner assembly **79** provides a supplementary mass flow of slightly re-pressurized and highly superheated ~~turbine~~ recycle exhaust gas (which now can be referred to as "working motive fluid gas") ~~mass flow~~ at controlled temperatures into conduit **83** having end connectivity to conduit **56**'s flanged connection **57**. The supplementary mass flow of slightly re-pressurized and highly superheated ~~turbine recycle exhaust gas mass~~ working motive fluid gas flow is routed through conduit **56** into branch conduit **41** having connectivity to WHRSG exchanger or WHRPF process fluid exchanger **42**, thereby enabling ~~a~~ an increased mass flow of steam or hot water or process fluids (in conduits **47**, **51**, and **54** at given desired temperature operating conditions) to be ~~additionally generated~~ transmitted ~~with high system thermal efficiency within~~ through the WHRSG or WHRPF ~~process fluid~~ exchangers **49** and **42** from the invention's ~~increased cogeneration system's~~ increased conduit **41** mass flows of highly superheated working motive fluid gas and conduit **45** ~~recycled~~ recirculated exhaust gas mass flows of lesser superheat gas temperature.

Within the presented invention's ~~partially-open~~ improved power cogeneration system method, the slightly superheated ~~turbine~~ partially-open cycle gaseous thermal fluid's recycle exhaust gas mass flow within conduit **11** remains at a constant flow rate for steady-state example hot gas expansion turbine ~~power~~ shaft horsepower output production. The excess slightly superheated ~~turbine~~ recycle exhaust gas mass flow within manifold **10** that is not required for steady-state ~~turbine~~ power production, nor is

required to maintain an existing steady-state recycle exhaust gas mass flow rate within conduit **68** for the ~~fired~~ oxy-fuel fired combustion ~~heater~~ burner assembly **79**, is flow-directed from manifold 10 through side-branch conduit **58** that can contain ~~containing~~ back pressure control valve **59** and flow control/isolation valve **60** with downstream connectivity to atmosphere occurring at vent point **61**.

The numbers in Table 2 below are representative of: one example set of fluid stream conditions in which the thermal fluid energy cycle contained ~~AES turbine power cycle portion~~ within the presented power cogeneration method system can operate (the conduit streams are those identified by the numbers in Fig. 1). The following assumptions were made: ~~both~~ the recycle gas compressor efficiency and hot gas expansion turbine efficiency ~~is~~ are both 84%; the oxy-fuel combustion burner assembly operating pressure is 60 psia; and the methane fuel gas flow rate is 1 Mol/minute.

TABLE 2

Conduit Stream Number	Stream Fluid	Temperature Degree F.	Pressure PSIA	Mass Flow lbs./Min.
11	Recycle Exhaust	197	15	1879
12	Compressed Recycle	500	64	1879
22	WMF – Primary Zone	1350	63	686
21	WMF – Tertiary Zone	1350	63	1153
23	Cooled Compressed Recycle	280	63.5	40
32	Methane Fuel	70	85	16
35	Predominant O.sub.2	110	65	64

30	Combustion Working Motive Fluid	1800	60	1959
37	Turbine Engine Exhaust	1391	15.8	1959
45	WHRU & WHRSG Exhaust	530	15.4	1959
58	Cogen System Method Vent Gas	197	15.1	81

(WMF) = Working Motive Fluid

With the same example stream conditions and assumptions made for Table 2, supra, Table 3 provides the thermodynamic values from which the tabulated compressor horsepowers and example ~~turbine~~ power engine unit power outputs are derived.

TABLE 3

Conduit Stream ** Number	Rotating Equipment Name	Stream Fluid	Temperature Degrees F	Mass Flow lbs./Min.	Delta Enthalpy Btu/Lb.	Horse-Power (HP)
11 to 12	Exhaust	Inlet	197			
	Recycle			1879	98.9	4377
	Compressor	Discharge	500			
30 to 37	Hot Gas	Inlet	1800			
	Expander			1959	169.7	7837
	Turbine	Discharge	1391			
				Net Shaft Horsepower Output		3460 SHP *

(*) Note: (20,693,400 LHV Btu/Hr-Mol CH4) ÷ 3460 SHP = 5980 Btu/Hp-hr. fuel rate.

(*) Note: Fuel Rate: (2545 Bt/Hp-hr.÷ 5980 Btu/Hp-Hr. = 42.55% turbine engine thermal efficiency:

(**) Note: Only the conduit stream numbers reference to both Figure 1 and Figure 2 drawings.

With the same conditions and assumptions made for Table 2, supra, Table 4 contains six conduit streams (as noted) that appear in both Fig. 1 and Fig. 2, with the thermal heat transfers and mass flow rates pertaining only to the Fig. 1 presented improved power cogeneration method system and apparatus assemblies.

TABLE 4

Conduit Stream Number	Heat Exchanger Name	Stream Fluid	Temperature Change Degrees F	Mass Flow lbs./Min.	Delta Enthalpy Btu/Lb.	Recovered Heat Rate Btu/Min.
37 to 45	18 + 42	Total Exhaust	1391F to 530F	1959	326	638,634
38 to 39	WHRU 18	Exhaust Gas	1391F to 530F	1805.15	326	588,480
13/14 - 21/22	WHRU 18	'WMF' Gas	500F to 1350F	1839	320	588,480
41 to 43	WHRSG 42	Exhaust	1391F to 530F	153.85	326	50,154 *
45 to 10	WHRSG 49	Exhaust	530F to 197F	1959	110	215,490 *

*Total Available Heat for Process Gas or Steam Circuit = (215,490 + 50,154) = 265,644 Btu/Min.

*Total Available Heat for Process Gas or Steam Circuit= ~~(215,490 + 50,154)~~ (265,644 Btu/Min. x 60) = 15,938,640 Btu/Hr.

Total 910 Btu/SCF LHV of 1 Mol/Min. Methane Fuel Gas = 344,890 Btu/Min. = 20,693,400 Btu/Hr.

Recovered Heat Rate from the Supplied Fuel Gas Energy:

= (15,938,640 Btu/Hr ÷ 20,693,400 LHV Btu/Hr-Mol Methane Gas) = 77.02%.

Total Improved Cogeneration Method System Thermal Efficiency:

= 42.5% Simple Cycle Turbine Power Engine Unit Energy Conversion Efficiency

+ 77.02% Recovered Heat Rate

= 119.5%.

With the same conditions and assumptions made for Table 2 and 4 supra, Table 5 provides the thermal heat transfers and mass flow rates as contained within the Alternative Cogeneration Method System of Fig.2 with added supplementary heat blended into the ~~turbine~~ hot gas expansion turbine exhaust stream to increase the cogeneration method system's apparatus assemblies effective transfer of heat to steam or process heated fluids by the example amount of 100%.

TABLE 5

Conduit Stream Number	Heat Exchanger Name	Stream Gas	Temperature Change Degrees F	Mass Flow lbs./Min.	Delta Enthalpy Btu/Lb.	Recovered Heat Rate Btu/Min.
38 to 39	WHRU 18	Turbine Exh.	1391F to 530F	1805	326	588,480
13/14 - 21/22	WHRU 18	'WMF' Gas	500F to 1350F	1839	320	588,480
41/83 - 43	WHRSG 42	Exhaust	1391F to 530F	763	326	248,738 *
45 to 10	WHRSG 49	Exhaust	530F to 197F	2568	110	282,480 *
10 to11		Recycle		1879		
10 to 68		Recycle	197F	556		
10 to 61		Exhaust Vent		138		
35 + 84		95% Oxygen Mixture	120F	112		
32 +86		Methane Fuel	70F	26		

*Total Available Effective Energy Conversion to Heat for Process Gas or Water/Steam Circuit:

= (248,738+ 282,480) = 531,218 Btu/Min. = 31,873,080 Btu/Hr.

<u>Turbine Power Apparatus Effective Energy Conversion Rate = (2545)x(3460 SHP) = 8,805,700 Btu/Hr</u>.

Total Effective Energy Conversion Rate = 40,678,780 Btu/Hr.

Total System Fuel Energy Consumption:

(20,693,400 LHV Btu/Hr. for Turbine Apparatus+ 12,993,602 LHV Btu/Hr for Supplementary ~~AES~~ <u>Oxy-Fuel</u> Burner System) = 33,687,002 LHV Btu/Hr.

Overall System Thermal Efficiency: (40,678,780 Btu/Hr.) ÷ (33,687,002) = 120.75%

It should be understood that the forgoing description is only illustrative of the invention. Various <u>altered method</u> system and apparatus alternatives, fuels, and modifications to operating conditions can be devised by those skilled in the art without departing from the invention. Accordingly, the present invention is intended to embrace all such alternatives, modifications and variances which fall with the scope of the following appended claims.

I claim:

1. A power cogeneration partially-open oxy-fuel combustion cycle method and system having recirculated gaseous thermal fluid and apparatus devices for conversion of hydrocarbon fuel heat-value energy into mechanical energy power and transferable residual exhaust energy for useful purposes, comprising:

(a) a partially-open oxy-fuel combustion cycle method containing a continuously recirculated superheated gaseous thermal fluid;

(b) one or more combustion chamber apparatus assembly or subassembly device wherein temperature controlled oxy-fuel combustion takes place;

(c) one or more integral power engine unit apparatus assembly device wherein hydrocarbon fuel heat-value energy is converted into mechanical power energy and exhaust gas residual energy for useful heating of other gaseous or liquid fluids;

(d) an integral power unit apparatus device therein containing, but not limited to, a recycle gas compressor apparatus assembly or subassembly device, one or more oxy-fuel combustion chamber assembly or subassembly device, and a hot gas expansion power extraction assembly or subassembly device;

(d) two or more alternative power engine unit apparatus assemblies or subassembly devices collectively performing identical energy conversion step functions as those performed within an integral power engine unit apparatus assembly;

(e) one or more heat exchanger assembly devices, wherein

1. a quantity of heat energy is extracted from one cited cycle recirculated gaseous thermal fluid stream and transferred to either one or more other cited cycle recirculated gaseous thermal fluid stream,

2. a quantity of heat energy is extracted from one cited cycle recirculated gaseous thermal fluid stream and transferred to one or more other supply/return fluid streams originating from outside the partially-open cycle and cogeneration system, and

3. the heat exchanger assembly contains one or more sections, each section therein having fluid heat transfer coils;

(f) a valve apparatus device for controlling individual flow streams of fuel and a predominant oxygen mixture gas stream entering into the cited partially-open cycle and power cogeneration system from remote supply sources;

(g) the power cogeneration system therein having control means for controlling an excess flow stream portion of the partially-open cycle's recirculated gaseous thermal fluid stream, the said excess controlled stream portion thereafter exhausted from within the cited cycle and vented to atmosphere;

(h) the power cogeneration system having conduit means therein providing for fluid flow communication between individual apparatus devices, and between apparatus devices within the system and other supply/return fluid streams originating from outside the partially-open cycle's boundary limits;

(i) an alternative system addition of apparatus devices therein independently supplementing the production flow of oxy-fuel combustion exhaust gas flows within a conduit manifold having communication to one or more exhaust waste heat recovery exchanger device; and

(j) a power cogeneration system PLC control panel device having monitoring and control communication with instrumentation and fluid flow control devices mounted to and/or positioned within cited conduits and apparatus devices, all said devices

complying with industry and governmental codes/ standards for safe operation and acceptable operating reliability.

1. ~~A partially-open extra-ordinary low operating pressure power cogeneration system and apparatus means employed to convert supplied fuel energy sources into mechanical or electric energy and wherein the system accompanying developed residual thermal heat energy from one or more portions of the described system are usefully transferred to other facility supplied thermal fluid streams connected to the system, the said partially-open system and apparatus means hereafter referred to as the AES Power Cogeneration System comprising:~~

~~(a) a partially-open power cogeneration system having controlled mass flow streams of low pressure working motive fluid gases and power system exhaust that comprises a highly superheated preferred mixture of predominant carbon dioxide and water vapor in Mol percent ratio proportions identical to that of the carbon dioxide and water vapor generated from oxy-fuel combustion of a preferred gaseous or liquid hydrocarbon fuel;~~

~~(b) a partially-open power cogeneration system having a heavily predominant portion of its highly superheated temperature turbine exhaust heat transferred to the low pressure working motive fluid to develop a working motive fluid temperature that is slightly less than the temperature of the exhaust gases exiting from the power turbine assembly, thereby greatly contributing to the system's unconventionally high thermal efficiency;~~

~~(c) a modified conventional gas turbine assembly unit or other alternative combined individual series-connected equipment apparatus means that therein can re-pressurize a heavily predominant and controlled flow portion of low superheat~~

~~temperature re-circulated oxy-fuel combustion system exhaust gases that are subsequently greatly increased in temperature to form the working motive fluid;~~

~~(d) a partially-open power cogeneration system having individual flow controlled low pressure streams of highly superheated working motive fluid gases introduced into the system's oxy-fuel fired combustion burner assembly where therein the working motive fluid gases are mixed with valve-controlled streams of fuel and predominant oxygen to produce a high velocity stream of increased temperature superheated working motive fluid composition combustion gases that are directed through hot gas expansion power turbine assembly means to produce mechanical output power and residual superheated exhaust gas thermal energy, said mechanical output power produced at unconventionally high simple-cycle thermal efficiencies;~~

~~(e) one or more AES Power Cogeneration System exhaust residual heat recovery exchanger means for maximizing the overall system's unconventionally high thermal efficiencies;~~

~~(f) a power cogeneration system and apparatus means wherein during steady-state system operation, the open-portion of the cycle comprises the valve-controlled venting of excess low superheat temperature re-circulated system exhaust gases therein having a mass flow rate equivalent to the combined mass rates in which controlled flow streams of fuel and predominant oxygen gas mixture are admitted into the system apparatus' oxy-fuel combustion burner assembly;~~

~~(g) a power cogeneration system and apparatus means with alternative added supplementary heater apparatus within the closed-portion of the system whereby the production quantity of steam or heated water or heating of process fluids for a facility~~

~~can be independent of the amount of residual exhaust heat being produced by the turbine power producing portion of the system;~~

~~(h) a partially-open power cogeneration system having individual first and second controlled low pressure flow streams of highly superheated working motive fluid gases introduced into the system's oxy-fuel fired combustion burner assembly, said second controlled stream providing the means for controlling a combined preset maximum primary combustion flame zone and outer secondary zone equilibrium temperature, said first stream providing the means for a controlling a tertiary zone temperature flow of exhausted working motive fluid composition gases that are directed into the downstream inlet of the hot gas expansion turbine assembly;~~

~~(i) a power cogeneration system and apparatus means with master PLC based control panel and system devices employed for the safe control and monitoring of fluid stream flow conditions and operating apparatus equipment in accordance with accepted industry published standards and governmental codes;~~

2. The partially-open oxy-fuel combustion cycle method's recirculated superheated gaseous thermal fluid of claim 1 further comprising:

(a) a gaseous fluid whose molecular gas composition remains unchanged throughout the cycle with a given employed fuel;

(b) a gaseous fluid continuing throughout the cycle in a superheated temperature gaseous state;

(c) a gaseous fluid composed of highly predominate binary carbon dioxide and binary water vapor exhaust gases; and

(d) a gaseous fluid of highly superheated temperature having the thermal characteristic of adsorbing or releasing approximately 40% more Btus of heat energy

per pound of gas per degree Fahrenheit change in gas temperature, as compared to conventional air/fuel combustion chamber exhaust gases.

2. ~~A partially open power cogeneration system and apparatus means of claim 1, wherein the individual second controlled low pressure streams of highly superheated working motive fluid gases introduced into the system's oxy-fuel fired combustion burner assembly therein provides the means for a controlled preset maximum primary inner flame and outer secondary combustion zone temperature that enables a non-distribution quality of gaseous or liquid hydrocarbon fuel (containing toxic and/or difficult to combust hydrocarbon molecular components) to be rapidly carried through a completed oxy-fuel combustion process for a useful heat conversion and/or completed incineration of said components.~~

3. The oxy-fuel combustion cycle method and apparatus devices of claim 1 further comprising:

(a) one or more oxy-fuel combustion chamber devices wherein temperature controlled combustion takes place, said combustion and generated heat of combustion dispersal being highly accelerated, thereby achieving an extremely rapid preset uniform equilibrium temperature of gases within the cited oxy-fuel combustion chamber;

(b) one or more oxy-fuel combustion chamber devices wherein temperature controlled combustion takes place, said combustion comprising a primary combustion flame zone wherein hydrocarbon fuel and oxygen chemical reactions produce extraordinary high superheated water vapor and carbon dioxide as products of said combustion;

(c) one or more oxy-fuel combustion chamber devices wherein a mass of generated extraordinary high superheated water vapor and carbon dioxide combustion

gaseous products radiantly emit their individual gas heat energy to other like gases therein adsorbing the cited radiated heat energy at the speed of light velocity of 186,000 miles per second;

(d) an ultra-low level of resultant generated oxy-fuel combustion exhaust emissions of nitrogen oxide and carbon monoxide gases achieved from a control of preset combustion chamber primary zone equilibrium temperature, said temperature being below that in which the cited exhaust emissions are produced from disassociation chemical reactions;

(e) the cited partially-open cycle containing a recirculated superheated gaseous thermal fluid, said gaseous fluid then re-pressurized or compressed by a cited recycle compressor and thereafter increased in superheat temperature to establish a cycle gas stream then referred to as a "working motive fluid" gas stream;

(f) the cycle's working motive fluid gas having mass flows, gas thermal characteristics, and highly superheated temperatures for the highly efficient conversion of thermal heat energy into mechanical power, and useful transfer of residual thermal energy to other fluid streams;

(g) an oxy-fuel combustion chamber having partial premix assembly means of co-mingling and/or homogeneously blending introduced controlled flow streams of working motive fluid gas, fuel, and predominant oxygen gas mixture for a resulting controlled ignition/combustion temperature of said fuel;

(h) an introduced individual controlled fluid stream of fuel, and of separate predominant oxygen mixture stream, into the partially-open cycle through conduit means originating from remote supply sources exterior to the recited cycle boundary limits;

(i) a mass mixture of pressurized working motive fluid gases introduced into the cited oxy-fuel combustion chamber and combined with fuel combustion product gases, the combined gases thereafter expanded through a apparatus device means to convert the said gases' thermal energy into mechanical power energy; and

(j) a steady-state partial-open thermal fluid energy cycle method wherein controlled conduit mass flows of excess recirculated exhaust gases, said gases exhaust-vented from the cited cycle to atmosphere, are in mass flow equilibrium with the combined mass flows of fuel and predominant oxygen mixture entering into cited cycle.

~~3. A modified conventional gas turbine assembly unit or other alternative combined individual series-connected equipment apparatus means that therein can re-pressurize a heavily predominant and controlled flow portion of low superheat temperature re-circulated oxy-fuel combustion system exhaust gases of claim 1, wherein the alternative means of re-pressurizing recycled system exhaust gases can be accomplished with separately-driven gas compressor apparatus means that can include compressor styles including those of the axial, centrifugal, or positive displacement types.~~

4. The cycle's recirculated superheated gaseous thermal fluid method of claim 1 further comprising:

(a) a method gaseous molecular mixture composed of highly predominate binary carbon dioxide and binary water vapor gases having a carbon dioxide Mol % to water vapor Mol % ratio therein being identical to the carbon dioxide Mol % to water vapor Mol % ratio of these products of combustion as generated by the combustion of a given hydrocarbon fuel; and

(b) a method gaseous molecular mixture predominately consisting of carbon dioxide and water vapor, with respectively lesser descending Mol percents of argon, excess

combustion oxygen, nitrogen, and rare atmospheric gases completing the total molecular composition of the thermal fluid's gaseous molecular composition.

~~4. A modified conventional gas turbine assembly unit or other alternative combined individual series connected equipment apparatus means that therein can re-pressurize a heavily predominant and controlled flow portion of low superheat temperature re-circulated oxy-fuel combustion system exhaust gases of claim 1, wherein a oxy-fuel combustion burner assembly means can comprise either one or more modified combustion chamber means within a conventional gas turbine unit design or can comprise a alternative modified conventional commercial/industrial burner assembly means designed for preferred axially-positioned close connection to a hot gas expansion power turbine assembly to produce mechanical output power and residual superheated exhaust gas thermal energy.~~

5. The integral power engine unit apparatus assembly device of claim 1 further comprising:

(a) An exhaust gas recycle compressor assembly or subassembly device connected by shaft means to a later described hot gas expansion power extraction assembly or subassembly device;

(b) One or more oxy-fuel combustion chamber/combustor assembly or subassembly device;

(c) A hot gas expansion power extraction assembly or subassembly device, therein converting an oxy-fuel combustion chamber assembly's discharged working motive fluid with gaseous thermal and pressure expansion energy into mechanical shaft output energy; and

(d) an emitted flow of reduced temperature working motive fluid exhaust gases, therein discharged into an exhaust conduit manifold connected to a later described downstream-positioned waste heat recovery exchanger means.

~~5. A partially-open power cogeneration system and apparatus means of claim 1, wherein the recited one or more AES Power Cogeneration System exhaust residual heat recovery exchanger means can comprise parallel-positioned exhaust residual heat recovery exchanger means that can have individual flow controlled exhaust flows through each exchanger having preferred flow-control damper valves or other means positioned in each exchanger's outlet exhaust gas conduit having a reduced temperature.~~

6. The two or more alternative power unit apparatus assemblies of claim 1 further comprising:

(a) an integral motor or steam turbine driven exhaust gas recycle compressor apparatus assembly, therein replacing the cycle function performed by the exhaust gas recycle compressor assembly or subassembly device within the fore-cited integral power engine unit apparatus assembly device; and

(b) an integral apparatus assembly containing an oxy-fuel combustion chamber subassembly connected to a hot gas expansion power extraction assembly or subassembly.

~~6. A partially-open power cogeneration system and alternative added supplementary heater apparatus within the closed portion of the system of claim 1, wherein an alternative added commercial/industrial oxy-fuel combustion burner assembly system can be close-connected to a present system's integrated heat exchanger inlet exhaust gas conduit to produce additional steam or hot water or process fluid heating~~

~~capacities, the said added alternative oxy-fuel combustion burner assembly system therein including exhaust gas blower means for slightly re-pressurizing a flow-controlled portion of the total cogeneration system's re-circulated exhaust at reduced superheat temperature for downstream subsequent blending with controlled flows of fuel and oxygen within the said burner assembly.~~

7. The heat exchanger assembly devices of claim 1 further comprising:

(a) a power engine unit exhaust waste heat recovery unit (WHRU) exchanger assembly conduit-positioned downstream of a power engine unit for transfer of power engine unit exhaust gas residual heat energy to fluid coils contained within two parallel exchanger sections contained within the WHRU exchanger assembly;

(b) a power engine unit 'first' exhaust waste heat recovery stream generator (WHRSG) exchanger assembly, or waste heat recovery process fluid (WHRPF) exchanger assembly, hereafter referred to as the WHRSG/WHRPF exchanger assembly positioned in parallel with the WHRU exchanger assembly and having conduit communication to a power engine unit's exhaust manifold;

(c) a power engine unit 'first' WHRSG/WHRPF exchanger assembly having conduit communication with the power engine unit exhaust manifold for the transfer of exhaust gas residual heat energy to fluid coils contained within the WHRSG/ WHRPF exchanger assembly;

(d) a power engine unit 'second' exhaust gas WHRSG/WHRPF heat exchanger assembly comprising

1. a heat exchanger assembly having a upstream common manifold conduit communication with the parallel connected WHRU and 'first' WHRSG/WHRPF exchanger assemblies,

2. a heat exchanger assembly discharging slightly superheated recirculated exhaust gas into a downstream exhaust gas distribution manifold means, and

3. a heat exchanger assembly transferring exhaust gas residual heat energy to hot water/steam coils or process fluid coils contained within the exchanger assembly;

(e) an air-cooled exchanger through which a small controlled stream flow portion of recited primary recycle gases is cooled and conduit-connected to one or more fore-cited oxy-fuel combustion chamber assembly.

~~7. A modified conventional gas turbine assembly unit or other alternative combined individual series-connected equipment apparatus means of claim 1, wherein the hot gas expansion power turbine assembly means can be either as employed in conventional gas turbine unit assemblies or alternatively comprising one of a variety of currently manufactured assembly configuration types of hot gas expander devices that are not employed within conventional gas turbine cogeneration facilities.~~

8. One or more combustion chamber apparatus assembly or subassembly device of claim 1 further comprising:

(a) a partial premix subassembly therein receiving controlled communicating flow streams of

1. a gaseous or liquid hydrocarbon fuel from a connected remote source,

2. a gaseous mixture of predominant oxygen gases from a connected remote source, and

3. a low gas flow stream of primary re-pressurized and slightly superheated recycle gas from a connected fore-cited air-cooled heat exchanger;

(b) an internal primary combustion zone within each oxy-fuel combustion chamber assembly therein receiving a communicating second flow stream of

working motive fluid from the fore-cited WHRU heat exchanger;

(c) an internal tertiary blending zone within each oxy-fuel combustion chamber assembly, therein receiving a communicating first flow stream of working motive fluid from the fore-cited WHRU heat exchanger.

~~8. A partially-open power cogeneration system of claim 1, wherein during steady-state system operation the cited open-portion of the system comprises the venting of excess re-circulated system exhaust gases and further wherein the system can be fully-closed during demand periods for increased system output capacity and/or the system apparatus means can be increased in rotating speed until a desired steady-state output condition is achieved and the system can resume its cited partially-open system operation.~~

9. An alternative cycle method and apparatus devices for independently supplementing the production flow of oxy-fuel combustion exhaust flows of claim 1 further comprising:

(a) one or more exhaust recycle gas blower and common oxy-fuel fired combustion burner assembly being parallel gas flow-positioned within the cycle to the power engine unit apparatus;

(b) an inlet to each gas blower being conduit-connected with a supply of 'exhaust recycle gas' withdrawn from the cycle system's exhaust gas distribution manifold;

(c) one or more gas blowers, where in the case of two parallel-positioned gas blowers, individual blower controlled gas discharge streams have conduit-connectivity respectively with a partial premix subassembly and a tertiary blending zone within a oxy-fuel fired combustion burner assembly;

(d) a controlled conduit flow stream of supplied predominant oxygen mixture gas and a controlled conduit flow stream of supplied fuel, wherein each said stream is

conduit end--connected with the oxy-fuel fired combustion burner assembly's partial premix subassembly;

(e) the oxy-fuel fired combustion burner assembly having an exhaust gas flow conduit connectivity to, and co-mingled with, the power engine unit exhaust gases contained within an exhaust conduit manifold having connectivity to the downstream positioned fore-cited WHRU and WHRSG/WHRPF heat exchanger assembly devices.

~~9. A partially open power cogeneration system of claim 1, wherein the recited master control panel can comprise expandable control and safety monitoring features for control integration with the power cogeneration system' complementing auxiliary apparatus systems' PLC control panels and a facilities power plant distributive control system (DCS), said safety monitoring and control design features being in accordance with American Petroleum Institute (API) specifications for industrial gas turbines (API 616) or aero-derivative gas turbines specification (API RP 11PGT), API 617 for centrifugal compressors (and applicable portions therein to be applied to hot gas expanders), API 619 for rotary positive displacement compressors, API 673 for special fans, added alternative safety monitoring as required both by API 560 for fired heaters for general refinery service and NFPA 85C for prevention of boiler and furnace explosions for collective control integration within a central power plant distributive control system (DCS), and other prevailing commercial, industrial, or other facility site governmental jurisdiction codes and standards.~~

10. a hot gas expansion power extraction assembly or subassembly device means of claim 5, wherein a compressed and highly superheated working motive fluid is expanded to a lesser pressure and temperature thereby creating mechanical energy, the hot gas expansion power extraction device configured as:

(a) a conventional rotating hot gas power turbine assembly or subassembly device having two or more power turbine wheel expander stages;

(b) a conventional rotating hot gas power turbine assembly or subassembly device having one or more first-positioned power turbine wheel expander stages with shaft direct-connected to a recycle gas compressor assembly;

(c) a conventional rotating hot gas power turbine assembly or subassembly device having one or more last-positioned power turbine wheel expander stages with direct-connected output mechanical drive shaft; and

(d) a less conventional rotating hot gas power turbine apparatus assembly or subassembly device having one or more power turbine wheel expander stages with direct-connected output mechanical drive shaft.

11. one or more integral power engine unit apparatus assembly device of claim 1 having a configuration comprising but not limited to either one of:

(a) a presented and described modified rotating gas turbine apparatus assembly;

(b) a presented and alternative described two or more combined modified conventional rotating apparatus assemblies in combination with a oxy-fuel combustion chamber assembly device;

(c) a modified reciprocating type engine apparatus assembly device having two or more subassembly devices therein including one or more reciprocating piston subassembly devices having articulating communication means with a rotating mechanical power output crankshaft means.

12. A conduit means of claim 1 providing for fluid flow communication between individual apparatus devices within the cited cycle, and further providing for fluid flow communication between apparatus devices within the cited cycle and cycle-remote fluid connection points of fluid supply and/or fluid return, said conduit means further comprising:

(a) Three or more selected conduit means therein containing fluid flow control valves or pressure control valves, and sensor/transmitter instrumentation devices having electronic signal communication with a power cogeneration system PLC type control panel;

(b) All conduits with interior flows of cycle gaseous thermal fluid therein having exterior conduit-connected insulation means for purposes of minimizing heat losses from the recited partially-open cycle, and for purposes of facility personnel safety; and

(c) sensor/transmitter instrumentation devices having electronic signal communication with a power cogeneration system PLC type control panel.

13. The recited sensor/transmitter instrumentation devices of claim 12 further comprising but not limited to:

(a) the cycle gaseous thermal fluid streams' temperature and pressure sensing devices as required for cycle control purposes,

(b) a fuel supply stream's pressure and temperature sensing device,

(c) an oxy-fuel combustion chamber assembly's primary combustion zone and tertiary zone discharge temperature sensing devices,

(d) the cycle gaseous thermal fluid streams' mass flow calculating devices as required for cycle and cogeneration method control purposes,

(e) a cycle gaseous thermal fluid's recirculated exhaust stream oxygen content sensing / calculating device, and

(f) a cycle oxygen supply source stream's pure oxygen content sensing / calculating device.

14. A power cogeneration system PLC type control panel of claim 12 further comprising but not limited to:

(a) the means of receiving electronic input data signals from sensor/transmitter devices, said signals having relevance to monitoring for safe operating conditions and the control of conduit fluid flows as required to meet cycle produced power output demands and demands for transferred waste heat to other cycle-exterior fluid streams;

(b) the alternative means of receiving electronic input data signals from a manufacturer's standard power engine unit PLC control panel, the said input data signals being power cogeneration PLC control panel integrated as necessary for the control and safe operation of the oxy-fuel cycle and complete power cogeneration system;

(c) the cited power cogeneration PLC control panel means of transmitting PLC computed electronic output data signals to the appropriate fluid flow control valves in response to cited input signals, a response output signal change including but not limited to

1. a change in output signal to the valve that control the flow of predominant oxygen mixture into the cited cycle, following a signal change from the oxygen sensor positioned in the cycle's recirculated exhaust manifold,

2. a change in output signal to the valve that controls the flow of fuel into the cycle, following a change in signal from the temperature sensor in the oxy-fuel combustion chambers' primary zone, and

3. a change in separate output signals to the separate valves that control the flows of fuel and predominant oxygen mixture into the cited cycle, and a change in signal to a recycle gas compressor's output flow control means, following a change of a facility's input signal corresponding to a change in facility power demand on the power cogeneration system.

Abstract

(Amended) A power cogeneration system employing a partially-open gaseous fluid cycle method and apparatus devices for oxy-fuel combustion conversion of a given hydrocarbon composition fuel's heat-value energy into mechanical or electrical power energy, and transferred useful heat energy, with accompanying large reductions of consumed fuel and undesirable exhaust emissions.

~~A partially-open power cogeneration system and apparatus means wherein the system's working motive fluid replaces the predominant air-derived nitrogen working motive fluid contained in a conventional gas turbine cycle as applied within a conventional cogeneration system. The working motive fluid comprises a mixture of predominantly carbon dioxide and water vapor in a Mol percent ratio identical to that of the same molecular components Mol percentages as generated from the oxy-fuel combustion of the hydrocarbon fuel used. The described power cogeneration system can provide a 95 to 100% percent reduction of fugitive nitrogen oxide and carbon monoxide mass flow emissions as emitted by present art gas turbines on a rated shaft-horsepower basis, and can further develop cogeneration power plant thermal efficiencies exceeding 115% at greatly reduced system operating pressures.~~

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